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NEW ISOTOPES: Er^{172} AND $Tm^{172(1)}$

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ABSTRACT

Two new isotopes, Er^{172} of half-life 49.8 $\pm$ 1 hr, and Tm^{172} of half-life 63.6 $\pm$ .3 hr, have been found. The mass assignment of Tm^{172} was proven by direct mass separation, and that of Er^{172} by genetic relationship. The Tm^{172} isotope was found to emit a 1.5 Mev β^- particle, γ-rays of 1.79, 1.44, 1.09, .40, .18, and .076 Mev and a K x-ray of .049 Mev. The mass assignments of Er^{165}, Er^{171}, and Tm^{171} were verified.

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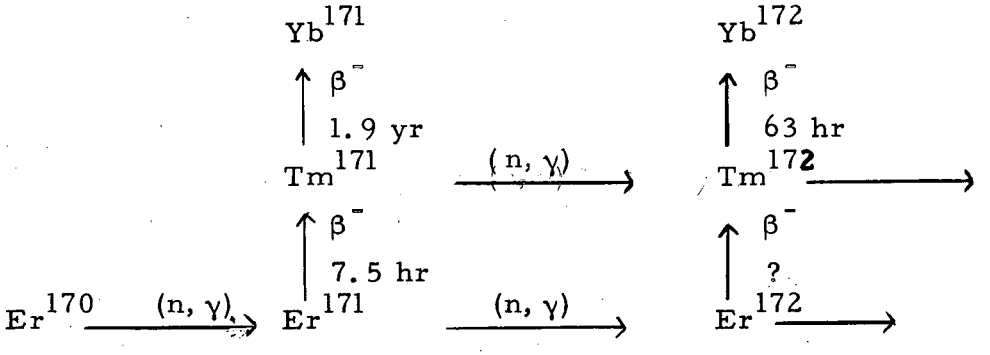
An unknown thulium activity with a 2-3 day half-life was first reported by Folger, Stevenson, and Seaborg.[2] During the course of some recent work on the high energy fission of uranium, this isotope was studied more closely and found to have a half-life of about 63 hr, and an erbium parent of about a 2 day half-life. It was decided to prepare enough of the thulium isotope for a mass separation so as to characterize the isotopes more completely.

Accordingly, 18 mg of Er_2O_3 were irradiated with neutrons for three days in the Materials Testing Reactor at Arco, Idaho. The expected reactions were



There were no interfering side reactions since there are no other active erbium isotopes decaying to active thulium isotopes.

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[1] This work was performed under the auspices of the Atomic Energy Commission.

[2] Folger, Stevenson and Seaborg, University of California Radiation Laboratory Report UCRL-1195 (revised) May 1951.

After irradiation the thulium was spearated from the erbium by means of an ion exchange column packed with Dowex-50 resin and eluted with 1.0M lactic acid of pH 3.10. Thirty percent of the thulium fraction was then mass separated, using a time-of-flight isotope separator in use at this laboratory. The mass 172 fraction had an activity of ~15000 dpm which decayed with a half-life of 64 hr. Least squares analyses of five Tm^{172} samples obtained from Er^{172}, formed both from uranium fission and by double neutron capture, gave an average of $63.6 \pm .3$ hr for the half-life.

In order to measure the half-life of the parent, Er^{172}, a series of column separations was made periodically to separate the thulium growing in from the main erbium fraction. Seven separations were made over a period of 14 days. It was necessary to correct for the thulium and erbium chemical yields and for the different growth times for each sample. The thulium chemical yields were determined by adding 2.7 mg of Tm^{169} carrier previous to each separation and weighing the final thulium sample as Tm_2O_3. The erbium chemical yields were determined by assaying the erbium fraction previous to each separation and counting the 9.4 day Er^{169} present.

The amount of radioactive daughter substance, N_2, present in an initially pure sample of the parent, N_1, at some time t is given by

$$N_2 = \frac{\lambda_1}{\lambda_2 - \lambda_1} N_1^{o} \left(e^{-\lambda_1 t} - e^{-\lambda_2 t}\right)$$

Thus a correction can be made for the different growth times by using the expression

$$N_2(\text{corr.}) = \frac{N_2(t_s)}{N_2(t)} = \frac{\left(\frac{\lambda_1}{\lambda_2 - \lambda_1}\right) N_1^{o} \left(e^{-\lambda_1 t_s} - e^{-\lambda_2 t_s}\right)}{\left(\frac{\lambda_1}{\lambda_2 - \lambda_1}\right) N_1^{o} \left(e^{-\lambda_1 t} - e^{-\lambda_2 t}\right)} = \frac{e^{-\lambda_1 t_s} - e^{-\lambda t_s}}{e^{-\lambda_1 t} - e^{-\lambda_2 t}}$$

Where t_s is some standard time chosen as a reference, and t is the actual growth time. The above expression was used to correct the growth of each sample to an arbitrary standard time of 48.0 hr. It was necessary to assume a value of λ_1 to obtain an approximate half-life and then make successive approximations. The corrected thulium activity is then, finally

$$A_{Tm}(\text{corr.}) = A_{Tm}(\text{obs.}) \left(\frac{e^{-\lambda_1 t_s} - e^{-\lambda_2 t_s}}{e^{-\lambda_1 t} - e^{-\lambda_2 t}} \right) \frac{1}{(\text{Tm yield})(\text{Er yield})}$$

where A_{Tm} (obs.) is the activity extrapolated to the time of separation.

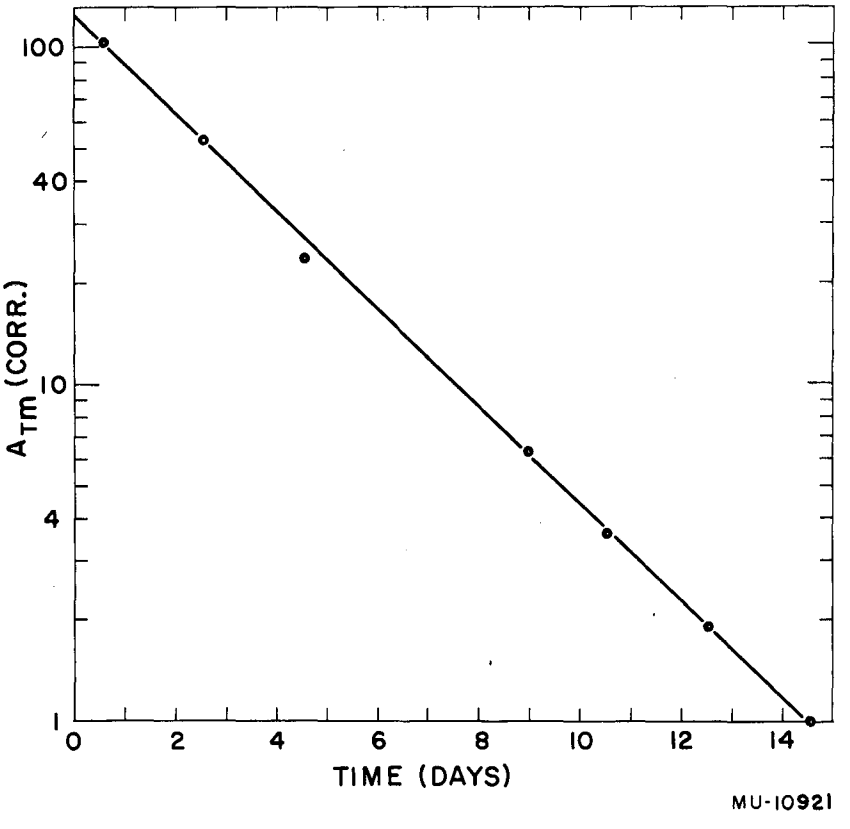
A plot was then made of the log of A_{Tm}(corr.) vs. the time to which the growth was corrected. A straight line resulted over a period of seven half-lives, as shown in Fig. 1. A least squares' analysis gave a value of 49.8 hr for the Er^{172} half-life. In consideration of the errors inherent in this milking technique, the probable error is set at $\pm$ 1 hr.

The β^- end point energy of Tm^{172} was estimated by means of an Al absorption curve, giving a value of 1.5 Mev. The γ-ray spectrum was investigated by using a 50-channel pulse height analyzer and a Tl activated NaI crystal. γ-rays of 1.79, 1.44, 1.09, and .076 Mev were found, in addition to the .049 Mev K x-ray. Two less prominent γ-rays of .40 and .18 Mev were also noticed.

In addition the mass assignments of 10 hr. Er^{165} and 7.5 hr Er^{171} were verified by a mass separation of 0.1 percent of the original erbium sample. The mass assignment of 1.9 yr Tm^{171} was also verified during the thulium run, by direct separation.

The authors wish to express their appreciation to the staff of the Materials Testing Reactor and of the 184-in and 60-in cyclotrons in Berkeley for their aid in making the irradiations.

Figure 1. A plot of A_{Tm}(corr.) vs time, to give Er^{172} half-life.


100
40
10
4
1
A_{Tm} (CORR.)
0
2
4
6
8
10
12
14
TIME (DAYS)
MU-10921