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THE FORMATION OF U^{232} BY HELIUM IONS ON THORIUM

by

Amos S. Newton

APR 14 1948

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THE FORMATION OF U^{232} BY HELIUM IONS ON THORIUM

Amos S. Newton
Radiation Laboratory
University of California, Berkeley, California

APR 14 1948

Abstract

The production of U^{232} by the sum of α,4n and α,p3n reactions on thorium has been studied. The cross section at an average energy of 37.5 Mev was 0.013 barns and the threshold for the reaction was about 30 Mev.

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Amos S. Newton
Radiation Laboratory
University of California, Berkeley, California

Gofman and Seaborg first produced the isotope U^{232} by deuteron bombardment of thorium[1]. Studier and Hyde[2] have reported the occurrence

1) Gofman, J. W., and G. T. Seaborg, PPR Vol. 17B, No. 2.4 (1946) (in press). First reported in Report CN-332, October 20, 1942.

2) Studier, M., and E. Hyde, PPR Vol. 17B, No. 9.2 (1946) (in press)

of the α,p3n reaction on thorium to give Pa^{232} which decays by beta emission to U^{232}. In neither of the above mentioned experiments was the cross section for formation of U^{232} determined.

In connection with work on the fission of thorium with helium ions[3],

3) Newton, A. S., "The Fission of Thorium by Helium Ions" (In press).

a long bombardment of a thick target was obtained from which it was possible to calculate the cross section and measure roughly the threshold for the formation of U^{232} by helium ion bombardment of thorium. From the active area of this target thin layers were milled, the millings from each respective layer collected quantitatively, weighed, dissolved in hydrochloric acid, and diluted to a known volume. About 6 months after bombardment, uranium was extracted from aliquots of each of these solutions by ether extraction of uranyl nitrate. The thorium aliquot was added to 1 ml concentrated nitric acid in a 30 ml Kjeldahl flask and boiled until fumes of NOCl were no longer evolved. Then 3 ml of 10 M ammonium nitrate were added and the solution extracted with 3 ml ether, the water phase being frozen in a dry ice-acetone bath to separate the phases. The ether was washed twice with 4 ml portions of 10 M ammonium nitrate. Three successive extractions

of the original sample were made and the ether extracts combined. To the combined ether extracts a few drops of concentrated nitric acid were added and the solution evaporated to eliminate the ether. The resulting solution was transferred to a platinum plate with a micropipette and the beaker and pipette washed three times with 3-drop portions of nitric acid. The solution on the platinum plate was evaporated under a heat lamp and then flamed to give samples for alpha counting. This method gave reproducible results and was probably quantitative for the uranium since further extractions of the sample gave no activity.

Since U^{232} decays by alpha-emission to $RdTh^{228}$ which has a 1.9-year half-life, measurements made soon after separation of the U^{232} are not contaminated with daughter products. To check for possible contamination from other alpha-emitters, samples from the first five layers were pulse analyzed and shown to contain no alphas of range differing from the 3.85 cm range of U^{232} (4), the range being checked against an ionium standard.

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4) James, R. H., A. E. Florin, H. H. Hopkins, and A. Ghiorso, PPR Vol. 14B, No. 22.8 (1946) (in publication).

Table I contains the data used in calculating the cross sections. In these calculations the half-life of U^{232} was taken as 70 years from the work of James, Florin, Hopkins, and Ghiorso (4). The initial 39 Mev energy of the alpha particles is degraded to an average energy of 37.5 Mev in the first layer. At this energy the average cross section for formation of U^{232} is 13.2 millibarns, this figure representing the sum of the cross sections for the α,4n and α,p3n reactions. No independent yields for these two modes of formation of U^{232} were obtained since the 1.4 day Pa^{232} had completely decayed at the time of the uranium separation.

TABLE I

The Yield of U^{232} from the Bombardment of Thorium with 39-Mev Helium Ions

Layer	Wt. Th in Layer gms.	Fraction of Layer Analyzed	α-Counting Rate at 52% Geom. c/m	σ (units 10^{-27} cm^2)	Thickness Th Layer mg/cm^2
1	0.380	.01	4544	13.4	44.2
		.01	4385	12.9	
2	0.408	.025	1336	1.2	47.4
		.025	1340	1.2	
3	0.332	.025	122	0.165	38.6
		.05	230	0.155	
4	0.640	.05	303	0.106	74.4
		.05	300	0.105	
5	0.612	.05	385	0.141	71.3
6	0.250	.05	140	0.125	29.1
7	0.411	0.1	401	0.11	47.8
8	0.396	0.1	187	0.053	46.1
9	0.252	0.1	55	0.024	29.3
10	1.082	0.1	38	0.004	126.0

Area target = 8.60 cm^2

Total bombardment = 3020 μah.

$T_{1/2}$ U^{232} = 70 years.

In figure 1, in which the cross section for formation of U^{232} has been plotted against the thickness of thorium, it is seen that there is apparently a deuteron contamination of the helium ion beam causing the production of U^{232} beyond the threshold for the helium ion reaction. The indicated yield is a minimum in the fourth layer indicating that the d,2n reaction probably

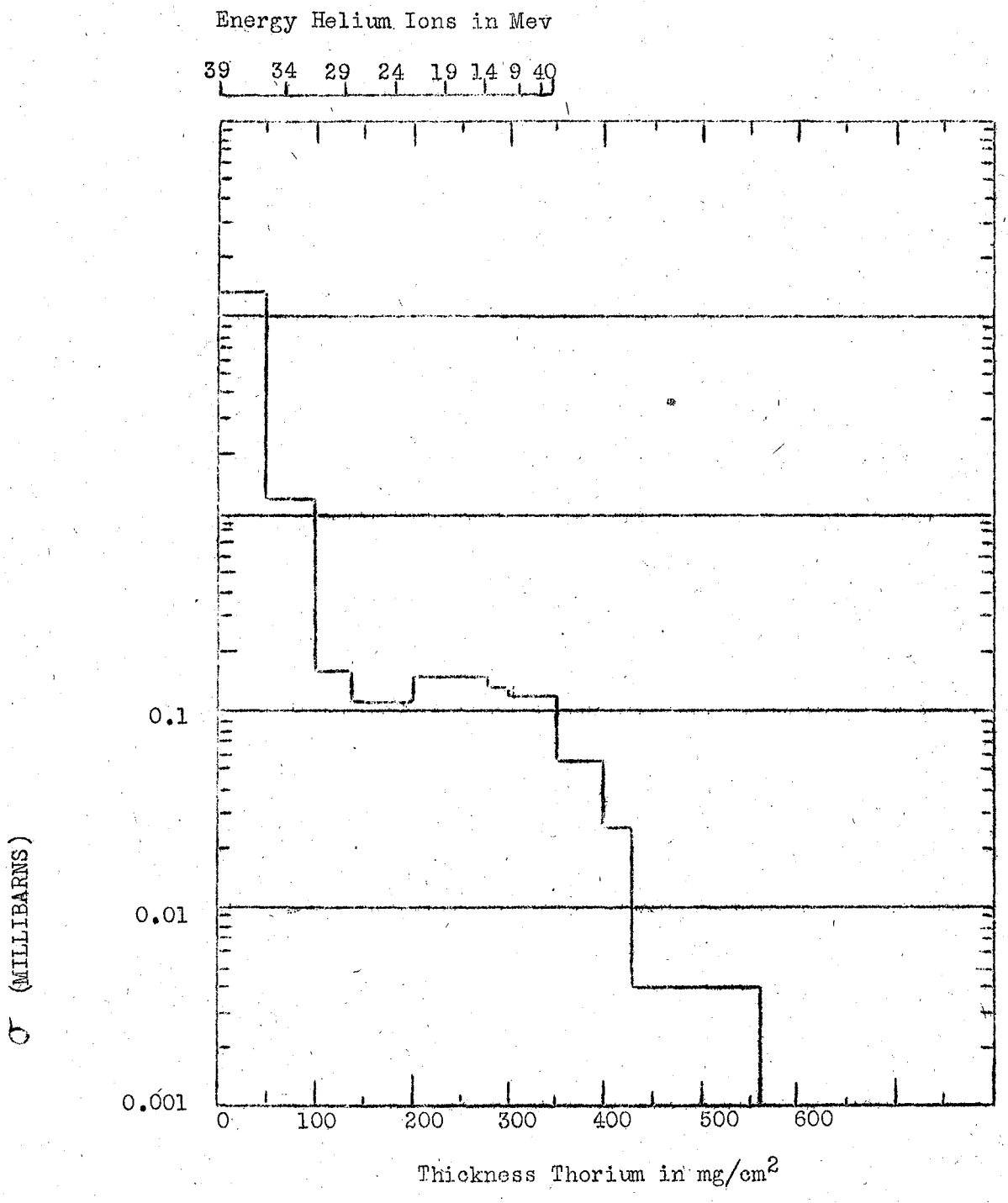

Figure 1.

CROSS SECTION FOR U^{232} PRODUCTION FROM THORIUM + HELIUM IONS

has a maximum yield in the fifth layer and some helium ion formation of U^{232} is still occurring in the third layer. This places a maximum value of 31.6 Mev and a minimum of 28 Mev on the threshold for the formation of U^{232} by helium ions, with an average value of 30 Mev. The yield from deuterons is observed to fall off rapidly when the thickness of thorium absorber becomes greater than 430 mg/cm^2 which corresponds to a reduction in energy of 20 Mev deuterons to about 10 Mev.

The author wishes to thank Mr. A. Ghiorso for making pulse analyses of the samples and Dr. J. G. Hamilton and the crew of the Crocker Laboratory cyclotron for bombarding the sample.

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