Memoirs of the College of Science, University of Kyoto, Series A,
Vol. XXVI, Nos. 1 & 2, Article 11, 1950.

Measurement of the Branching Ratio of Thorium C by a Photographic Method

By

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(Received July 15, 1950)

1. Introduction

It is well known that in the radioactive series of Thorium families a branching takes place in Thorium C; Th C may decay with the emission of either an α- or β-particle. The latest experiment to determine the branching ratio of the dual decay was performed by A. F. Kovarik and N. I. Adams (1) with an ionization chamber and a linear amplifier. They used specimens which were in radioactive equilibrium, and by counting the number, N_1, of α-particles from Th C′ and that, N_2, of all kinds of α-particles from the same specimens (α-rays from Rd Th, Th X, Tn, Th A and Th(C + C′)) in the same interval of time, they obtained the results that the ratio $N_1/\frac{1}{5}N_2$, i. e., Th C′/Th(C + C′) was 0.663. From this, we can see that 66.3 per cent of Th C nuclei decays with the emission of β-particles, while the remaining 33.7 per cent with the emission of α-particles.

2. Results of experiment

We performed an experiment to measure the branching ratio of Th C by a photographic method. One of the methods with photographic emulsions may be done by counting the number of Thorium stars* with five prongs, distinguishing the tracks of α-rays from Th C and Th C′. (One of the Thorium stars is shown in Fig. 1.) But there appear so many particles which pass out of the emulsion that the method requires much labour and moreover is not easy. So we turned to the following method.

* After we soak a plate in a solution of Thorium acetate or nitrate in water (1 per cent by weight) for ten minutes, and dry, leave in the dark for three days, and then develop, we can find in the plate many star-like tracks.

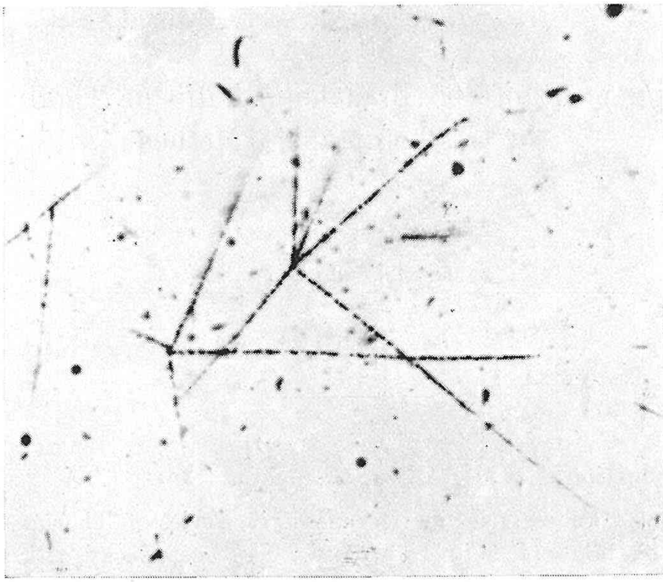
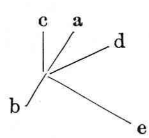


Fig. 1. Thorium stars (×1000)

(a)	RdTh	22.0 μ
(b)	ThX	23.6 μ
(c)	Tn	27.7 μ
(d)	ThA	31.2 μ
(e)	ThC′	47.2 μ



The method is to count the number of tracks of α-rays from ThC and ThC′ respectively in the same emulsion exposed to a specimen. We used a nuclear emulsion plate, Eastman Kodak NTB (50 microns thick), and a specimen of Thorium deposit which was formed on the surface of a copper disc and in which radioactive equilibrium had been established between ThB and ThC. After putting the emulsion face to face on the surface of the copper disc for some minutes, we developed. Thus, we could obtain many tracks of α-rays in the emulsion emitted only from ThC and ThC′. If we observe the tracks in the emulsion with a microscope, it is liable to miss some of the tracks. So we took photomicrographs of them magnifying 200 times. One of the photomicrographs is shown in Fig. 2. With this magnification we could photograph all of the tracks because of its deep focal depth. Then, the classification of these tracks was made possible from the following points of view.

In the first place, the stopping power of the emulsion being 1800, all the α-particles from ThC and ThC′ are considered to have their whole ranges in the emulsion. And as α-particles enter the emulsion with various angles, the tracks in the photomicrographs are their projections in the direction parallel to the surface of the emulsion. The range of α-particle from ThC in the photomicrograph being 0.52 cm (26.1 microns in the original emulsion), the tracks longer than 0.52 cm are attributed to ThC′ and all the other tracks to Th(C + C′) α-rays.

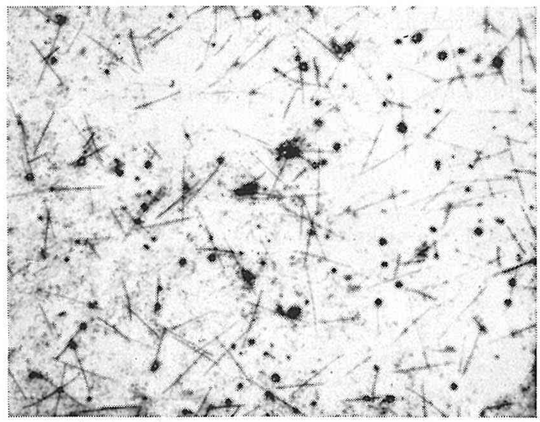


Fig. 2. Tracks of α-particles of ThC and ThC′ (×200)

In the second place, the angular distribution of α-particle emission is spherically symmetric. We have ascertained the fact by estimating the angle of dip of α-particle (the angle between the direction of the particle and the normal to the surface of the emulsion), measuring the length of each track longer than 0.52 cm in the photomicrographs. So, if the angle of dip is θ, when the length of ThC′ α track is 0.52 cm, the number of α-particles the tracks of which are not longer than 0.52 cm will be proportional to the solid angle $2\pi(1-\cos\theta)$ and that of longer $2\pi\cos\theta$. Therefore, the ratio of the number of tracks of ThC′ longer than 0.52 cm to that of not longer than 0.52 cm would be $(1-\cos\theta)/\cos\theta$. Since $\sin^{-1}26.1/47.3 = 33.4^\circ$ (the range of ThC′ being 47.3 microns in the emulsion), if the number of tracks longer than 0.52 cm is x, the number of α-rays from ThC′ may be given as $[1+(1-\cos\theta)/\cos\theta]\,x$, numerically $(1+0.198)\,x$.

We examined 27 sheets of photomicrographs the size of which was 6 cm × 10 cm, and counted 6792 tracks in total, of which 3739 tracks were longer than 0.52 cm. So, the number of ThC′ would be 4484 and the ratio of ThC′ to Th(C + C′) 0.6601 ± 0.0028. The results are nearly equal to that of Kovarik et al.

The characteristic of the photographic method is that we can count the number of tracks of α-particles emitted only by ThC and ThC′ in the same emulsion in the same interval of time.

Finally the author expresses his gratitude to Eastman Kodak Co. for their kind offer of the nuclear emulsion plates and Dr. B. Arakatsu and Prof. K. Kimura for their important advice, and Miss K. Ishii for her help in this work. This work is indebted to the Ministry of Education for research grant.

REFERENCES

1. A. F. Kovarik and N. I. Adams, Phys. Rev., **54** (1938), 413.