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RADIOACTIVE ISOTOPES OF TANTALUM AND WOLFRAM II

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Geoffrey Wilkinson

March 16, 1950

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RADIOACTIVE ISOTOPES OF TANTALUM AND WOLFRAM II

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March 16, 1950

The radiation characteristics of a 21.0-day wolfram activity produced in the bombardment of tantalum with protons and deuterons from the 184-inch cyclotron have been studied together with the characteristics of the 9.3-minute tantalum daughter of the wolfram activity.

Isotope	Decay	Half-life	Energy of Radiations Particles	γ-rays	Produced by
$Ta^{179,8}$	K,β^+,e^-,γ	9.35±0.05 minutes	0.08 e^- 1.06 β^+	L,K x-rays ~1.5	W^{179} 21.0 day K decay Hf - d - n, 2n
$W^{179,8}$	K,γ	21.0±0.2 days		L,K x-rays ~0.27 (weak)	Ta-p-3n Ta-d-4n

In a previous report,(1) a 21.0-day wolfram activity was described.

(1) G. Wilkinson and H. G. Hicks, UCRL-420 (August 18, 1949).

Greater intensities of this activity, available from a standby tantalum target bombarded with 50 Mev and lower energy protons from the 184-inch cyclotron, have allowed further measurements to be made. It is now shown that the wolfram activity decays by orbital electron capture to form a 9.3-minute tantalum daughter activity; the latter decays by both positron-emission and by orbital electron capture.

After initial separation of wolfram by the thiocyanate extraction method, with recovery as the yellow trioxide, the wolfram oxide was dissolved in 6N NaOH solution. The tantalum daughter activity was separated by scavenging the boiling alkaline wolframate solution with nickel hydroxide. The washed hydroxide was dissolved in acid, excess wolframate solution added and the boiling solution again made alkaline. The active tantalum was finally collected on a small amount of zirconium hydroxide by precipitation from hydrochloric acid solution by addition of ammonium hydroxide; the large amounts of nickel used as a scavenger remain in solution.

This simple separation of tantalum was found to be quantitative and, further, to give a decontamination factor of greater than 10^6.

9.35 ± 0.03 minute Ta^{179}

The decay of this activity separated from its wolfram parent was followed through fifteen half-lives. Aluminum, beryllium, and lead absorption measurements of the radiations were made; corrections for decay during the time of measurement were required. From the measurements, the radiations consist of electrons, total ranges in aluminum of 10 mg/cm^2 (~80 kev), ~420 mg/cm^2 (1.05 Mev), and electromagnetic radiations of half thickness ~16 mg/cm^2 aluminum (8.5 kev), 120 mg/cm^2

lead and ~2500 mg/cm^2 aluminum (58 kev), and ~15 g/cm^2 lead (~1.5 Mev). The energies of two soft electromagnetic components agree with those for L and K x-radiation of hafnium. Study on a simple beta-ray spectrograph showed conversion electrons of energy ~80 kev together with positrons of maximum energy .06 Mev.

The ratios of the various radiations obtained from the absorption measurements were corrected for absorption of radiations in air, counter window, etc., for counting efficiencies (for the argon-alcohol tubes used, counting efficiencies of 4 percent for L and 0.5 percent for K x-radiation and 1.5 percent for the 1.5-Mev γ-ray were assumed), and for loss of x-ray intensity by auger effect (coefficients of 0.5 for L and 0.8 for K x-radiations were assumed). Backscattering of soft electrons was minimized by mounting a very thin sample on thin mica.

The ratios obtained, necessarily approximate in view of the various assumptions made, are:

e^-	β^+	L x-rays	K x-rays	γ-ray
~0.5	0.03	~1	1	0.03

As discussed below, L and K x-radiation arise from both orbital electron capture in tantalum and from conversion in γ-ray transitions in the hafnium product, and it is reasonable to assume that ~0.5 of the K x-radiation results from orbital electron capture. On this basis, the 9.3-minute activity shows ~6 percent positron branching decay.

The 9.3-minute activity has been observed directly in the bombardment of hafnium with 10-Mev protons. Allocation of the 21.0-day wolfram parent is made to mass 179 or 178 on the basis of yields. Since a long-lived tantalum activity has been allocated to mass 179, the 9.3-minute activity may be an isomer. Since no long-lived activity has been observed to form from high intensities of the 9.3-minute activity, an upper limit for decay by isomeric transition can be set as 10^{-4} that for decay by orbital electron capture.

21.0 ± 0.2 day W^{179}

In order to obtain the radiation characteristics of the wolfram activity, the aluminum, beryllium, and lead absorption curves of the gross parent-daughter equilibrium mixture were measured. The daughter activity was then quantitatively separated and its activity measured. The equilibrium contribution of the 9.3-minute tantalum to the absorption curves of the gross activity were estimated, and the absorption of radiations of the wolfram parent obtained by subtraction.

The 21.0-day activity has electromagnetic radiations of half thickness ~17 mg/cm^2 aluminum (8.5 kev), ~130 mg/cm^2 lead (60 kev), and ~1200 mg/cm^2 lead (~0.27 Mev). No electrons were observed. The ratios of the various radiations corrected for counting efficiencies, auger effect, etc., are:

e^- : L x-rays : K x-rays : γ-rays <0.05 : ~0.8 : 1 : ~0.02

The isotope thus appears to decay by orbital electron capture.

From the measurements, the ratios of the L and K x-radiations for the 21.0-day and 9.3-minute activities can be readily obtained. The ratio of quanta emitted by the tantalum activity to quanta emitted by the wolfram parent activity was ~1.7 for K x-radiation and ~2.0 for L x-radiation. Thus, if it is assumed that one K x-ray quantum emitted by the wolfram activity represents one disintegration by orbital electron capture (only 0.75 L x-ray quanta are emitted per K electron captured due to direct transitions from M and lower shells), then it is clear that ~0.4 of the L and K x-rays of the 9.3-minute tantalum daughter must arise following K shell conversion in γ-ray transitions following orbital electron capture. This figure agrees roughly with the number of electrons per K x-ray observed in the tantalum activity.

No daughter activity other than the 9.3-minute tantalum activity has been found to grow from the 21.0-day wolfram isotope.

This work was carried out under the auspices of the U. S. Atomic Energy Commission.