Decay of Np^{241}†

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The decay of a 16-minute neptunium activity attributed to Np^{241} has been studied with anthracene and sodium iodide scintillation counters. The principal mode of decay appears to be a beta group decaying to the ground state of Pu^{241} with a beta end-point energy of 1.36±0.10 Mev.

THE 1953 Table of Isotopes[1] lists Np^{241} as a negatron emitter with a 60-minute half-life. Later experiments[2] with a time-of-flight mass separator showed that this activity was due to an isomer of Np^{240}. In a preliminary experiment, a sample was collected at mass 241 which showed both a 16-minute activity and a 3.3-hour activity, although fission product contamination was suspected.[2] However, neither of these activities were reported in a later study[3] of the spallation products from helium ion induced reactions of U^{238}.

The present work was initiated in the hope of clarifying the situation. Uranium foils of 0.001-inch thickness were bombarded with helium ions to search for Np^{241} which may be produced by the $U^{238}(\alpha,p)$ reaction. After irradiation, the foils were dissolved in acid. Neptunium was isolated by a chemical purification procedure which included co-precipitation with lanthanum fluoride, thenoyl trifluoroacetone (TTA) extractions, and anion exchange separations. Less extensive purification procedures failed to remove all fission-product contaminants. Neptunium samples counted with 2π and end-window proportional counters showed half-life periods of 16 minutes, 60 minutes, and 2.3 days. There was no indication of a three-hour activity. The neptunium samples were counted for about a month and no activities with half-life periods longer than 2.3 days were observed.

Short bombardments of 10 minutes duration with a helium ion energy of 32 Mev were performed for the study of the 16-minute activity. Under these conditions. the number of atoms produced of 16-minute Np^{241} and 60-minute Np^{240} was approximately equal. A 4-hour bombardment with a helium ion energy of 43 Mev was performed in a search for a 3.3-hour activity. From this experiment it was concluded that an upper limit for the cross section for production of the activity is approximately 0.2 mb.

The beta spectra of the short-lived activities were examined with a $\frac{1}{4}$-inch thick anthracene crystal. Calibration with the 629-kev Ba^{137} conversion electrons gave a peak width of 14%. The neptunium fraction was deposited on 5-mil mica sheets to reduce back-scattering. The composite spectrum, observed with a multichannel pulse-height analyzer, was divided into energy groups, each approximately 100 kev wide. Decay curves were resolved into the individual com-

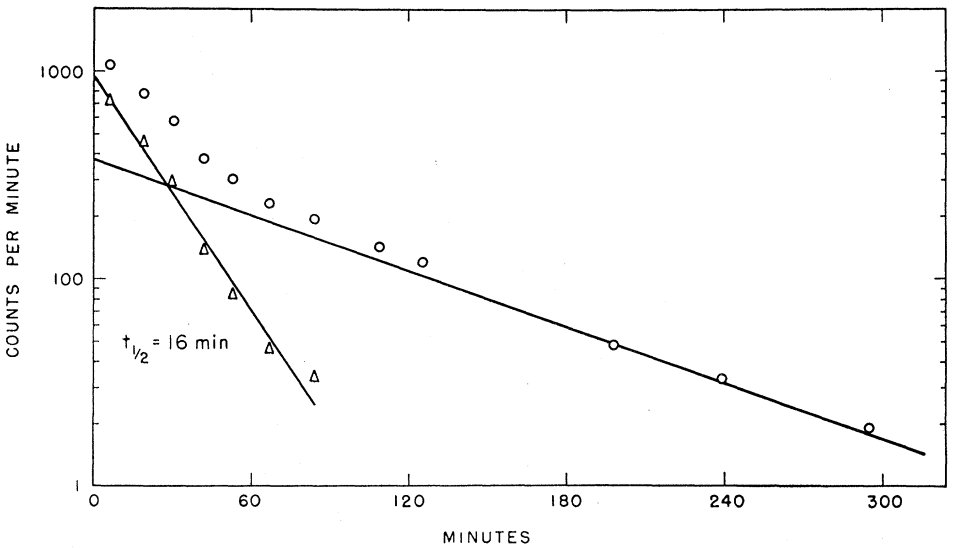

FIG. 1. Decay curve for the 660–750 kev beta-energy group observed with the anthracene crystal. The lower energy groups had a lower ratio of 16-minute to the 60-minute activity, and the higher energy groups had a higher ratio.

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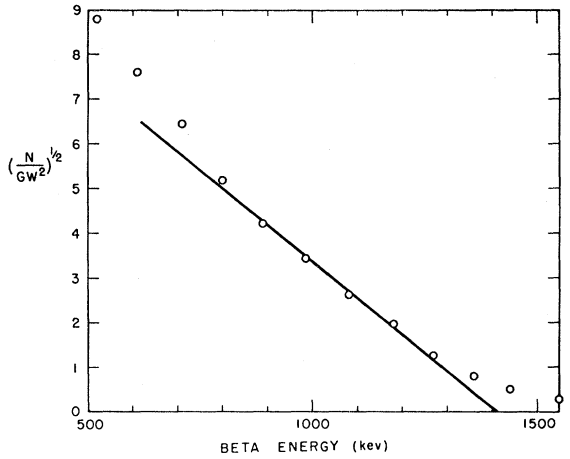

FIG. 2. Kurie plot of the beta spectrum of the 16-minute component. The channel width was 90 kev.

ponents for each energy group. A decay curve of one of the energy groups is shown in Fig. 1. The beta-spectrum end point for the 60-minute component was found from an average of two experimental determinations to be 0.86 Mev, in good agreement with a previous determination.[1] The beta-spectrum end point for the 16-minute component was determined to be 1.36 ± 0.10 Mev in the same experiments. A Kurie plot for the 16-minute component is shown in Fig. 2. Kurie plots for beta spectra obtained with anthracene crystals usually deviate from a straight line for beta energies below one-half the beta end point. The Kurie plot obtained for the 16-minute component began to deviate slightly earlier than expected, and when resolved, indicated a lower-energy group with an end point at about 0.9 Mev. The gamma-spectrum was examined with a $2\frac{1}{2}$-in. by $2\frac{1}{8}$-in. thallium-activated sodium iodide crystal. No gamma rays or K x-rays (resulting from internal conversion) were observed, which could be attributed to the 16-minute activity, although low-intensity transitions could have easily been missed in the complex spectrum from the decay of the 60-minute Np^{240} and 2.3-day Np^{239}. The 0.9-Mev beta group observed in the 16-minute component is probably due to incomplete resolution of the 60-minute Np^{240}.

The beta-spectrum end point of 1.36 Mev is in good agreement with the decay energy of 1.32 Mev predicted from closed decay energy cycles[4] for Np^{241}, supporting the mass assignment. The logft value calculated assuming all the decay goes to the ground state is 5.8, indicating an allowed transition. The nuclear spin of the daughter Pu^{241} has been measured[5] to be $\frac{5}{2}$. Np^{241} might be expected to have the same spin as Np^{237} and Np^{239}, as these isotopes all have an unpaired 93rd proton. The spin of Np^{237} has been measured[6,7] to be $\frac{5}{2}$. The spin of Np^{239} was first measured[8,9] to be $\frac{1}{2}$. However, a later measurement[10] indicates a spin of $\frac{5}{2}$, which is more consistent with the decay scheme proposed for the beta decay of Np^{239}.[11] The logft value of 5.8 for Np^{241} is more consistent with a spin of $\frac{5}{2}$ than $\frac{1}{2}$ for Np^{241}, although other possibilities exist.

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