New Gamma Rays in the Neptunium-239 Decay

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Two unreported gamma rays of energy 0.44 and 0.49 Mev are assigned to Np^{239} by reason of chemical properties and decay constant. The intensities of these gamma rays relative to a previously reported Np^{239} gamma at 0.334 Mev have been determined to be $\gamma_1(0.33\text{ Mev}):\gamma_2(0.44\text{ Mev}):\gamma_3(0.49\text{ Mev})=100:0.40:0.50$. Measured yields (gamma rays per decay) for the 0.44- and 0.49-Mev gammas are 1.6×10^{-4} and 1.9×10^{-4} gamma rays per decay. It seems probable that both of these gamma rays originate from a single Pu^{239} level at 0.49 Mev.

SEVERAL high-activity samples of Np^{239} were obtained by ion exchange separations from neutron-irradiated uranium. The neptunium was purified by repeated anion exchange on Dowex *A*-1 resin[1] and by *TTA*[2] extraction. Reduction to the Np(IV) valence state necessary for the separations was made with ferrous sulfamate.

Each sample, when observed with a gamma-ray scintillation spectrometer, was found to emit gamma rays of energy 0.44 and 0.49 Mev. These gammas were of very low intensity compared to the lower-energy Np^{239} radiation, so lead absorbers were used to eliminate pileup of pulses from low-energy gamma rays while maintaining a reasonable counting rate at the higher energies. Figure 1 shows a spectrum obtained with a $1\frac{1}{2}$-inch diameter by 1 inch thick NaI(Tl) crystal through a 8.12-g/cm^2 lead absorber.

The decay of these gamma rays relative to a known Np^{239} gamma at 0.334 Mev[3] was followed intermittently for twelve half-lives by comparing peak counting rates. The relative half-lives of the Np^{239} gamma ray and the new gamma rays were found to differ by no more than 0.3%. The decay data and chemical separations justify assignment of these gamma rays to the Np^{239} decay.

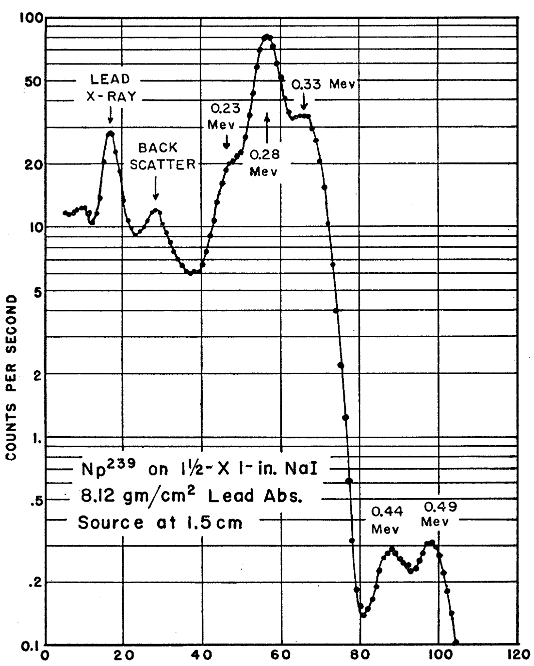

FIG. 1. Gamma-ray spectrum of Np^{239} from a NaI(Tl) scintillation spectrometer.

By correcting for the variation with energy of counter efficiency and lead transmission, it was possible to determine the intensities of the 0.44- and 0.49-Mev gamma rays relative to the intensity of the 0.33-Mev gamma ray. These values are included in Table I.

The gamma-ray yields (gamma rays per decay) were determined from measured counting efficiency and source activity. The counter efficiency was determined at 0.411 Mev by counting a calibrated Au^{198} source in the same geometry as the Np^{239} sample. By correcting the measured efficiency to 0.44 and 0.49 Mev, the total emission rate of the 0.44- and 0.49-Mev gamma rays was determined. The total neptunium source activity was obtained from a 4π beta count of an aliquot of the Np^{239} sample. The gamma-ray yields of the 0.44- and 0.49-Mev gamma rays are included in Table I. The gamma-ray yields are somewhat less accurately determined than the relative intensities. The errors quoted for relative intensity and gamma-ray yield are estimates of probable error including uncertainties of lead transmission and counter efficiency corrections.

TABLE I. Relative intensity and absolute yield of two high energy Np^{239} gamma rays.

$E\gamma$ (Mev)	Relative intensity	Yield (gammas per decay)
0.334	100	···
0.440	0.40±0.05	$(1.6\pm0.5)\times10^{-4}$
0.490	0.50±0.05	$(1.9\pm0.5)\times10^{-4}$

It seems probable that both the 0.49- and 0.44-Mev gamma rays originate from a single Pu^{239} level at 0.49 Mev, the 0.44-Mev gamma ray going to the 0.049-Mev level. Any lower energy gamma rays from this level would be obscured in the intense low-energy radiation accompanying the higher-yield beta-ray groups.

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[1] Dow Chemical Company, Midland, Michigan.
[2] Thenoyl trifluoro acetone as a 0.5 molar solution in xylene.
[3] Hollander, Perlman, and Seaborg, *Tables of Isotopes*, Revs. Modern Phys. **25**, 607 (1953).