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Curium Isotopes 246 and 247 from Pile-Irradiated Plutonium†

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Mass spectrometric analyses show the presence of curium-246 and curium-247 in curium samples produced from neutron-irradiated plutonium. The pile-neutron capture cross sections of Am^{243}, Cm^{244}, Cm^{245}, Cm^{246} are 115±20, 25±10, 200±100, and 15±10 barns, respectively. The alpha-disintegration half-life of Cm^{244} is calculated to be 19.2±0.6 years.

THE curium produced by the irradiation of two plutonium samples (total integrated fluxes 4×10^{21} and 8×10^{21} neutrons) in the Materials Testing Reactor (MTR) was chemically purified from fission products and other actinide elements. The plutonium was removed by utilizing its multivalent character.[1] The transplutonium elements were freed of fission products by standard cation resin column techniques.[2] Finally, the curium was separated from americium and the transcurium elements by an ion-exchange column of Dowex 50 resin in the ammonium form eluted with $0.25M$ citrate solution at a pH of 3.3 at 87°C. The column was 20 cm long with a cross-sectional area of 0.1 square cm. The actinide elements elute at different rates and the various fractions were collected and repurified.

The curium samples were analyzed in a 12-in., 60° mass spectrometer with a multiple filament source. The mole percent of the curium isotopes detected in each sample are given in Table I.

Sample I contained 0.24 percent Cm^{246}, whereas sample II contained 1.27 percent Cm^{246} and 0.016 percent Cm^{247}. Both curium samples also contained Cm^{245}, whose decay characteristics were recently identified.[3] The Cm^{247}/Cm^{244} ratio in sample II was constant within experimental error over a three-week interval. Cm^{247} is therefore either beta-stable or has a half-life greater than 2 months.

TABLE I. Mass spectrometric analyses of curium isotopes in mole percent (curium produced from plutonium irradiated in MTR).

Cm isotope	Sample I (Total flux 4×10^{21} neutrons)	Sample II (Total flux 8×10^{21} neutrons)
Cm^{242}	16.8 ±0.3	1.84 ±0.04
Cm^{244}	82.1 ±0.3	95.51 ±0.07
Cm^{245}	$0.93^{+0.10}_{-0.02}$	1.27 ±0.04
Cm^{246}	0.24±0.01	1.36 ±0.04
Cm^{247}	<0.004	0.016±0.002
Cm^{248a}	...	...
Cm^{249}	...	<0.002
Cm^{250}	...	<0.002

a The abundance of Cm^{248} metal ions could not be determined due to the interference of the impurity ThO^+ (mass = 248).

The mass-spectrometric mole ratio of Cm^{244} to Cm^{242}, in conjunction with an alpha pulse analysis and a known alpha half-life of 162.5 days for Cm^{242}, enables one to calculate the alpha half-life of Cm^{244}. The data from the two curium samples give an alpha half-life of 19.2±0.6 years for Cm^{244}.[4]

Pile-neutron capture cross sections have been calculated for Am^{243}, Cm^{244}, Cm^{245}, and Cm^{246}. A value of 115±20 barns for the pile-neutron capture cross section of Am^{243} was calculated from the relative quantities of Am^{243} and Cm^{244} present at the end of the irradiations. This value is higher than the value of 50 barns reported by Street *et al.*[5] but in agreement with a more recent measurement by Thompson.[6] The pile-neutron capture cross sections of Cm^{244}, Cm^{245}, and Cm^{246} calculated from the mass spectrometric data are 25±10, 200±100, and 15±10 barns, respectively. A previous value of <5 barns[7] for the Cm^{244} pile-neutron capture cross section is in disagreement with the present results. The high ratio of curium-246 to curium-245 indicates that Cm^{245} has a high destruction cross section. The binding energy of the last neutron in Cm^{246} is of the same order of magnitude as that of the last neutron in Pu^{242}. From fission systematics, one predicts that the thermal neutron fission-to-capture ratio[8] of Cm^{245} is greater than one. The large predicted thermal neutron fission cross section is in qualitative agreement with the recent thermal neutron fission measurements on Cm^{245}.[9]

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† These isotopes of curium have previously been discovered in other work at Argonne National Laboratory, not yet published.

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