Alpha Half-Lives of Cm^{244}, Cm^{245}, and Cm^{246}

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The alpha half-lives of Cm^{244}, Cm^{245}, and Cm^{246} measured from mass spectrometric analyses of curium and its plutonium daughters are 18.4±0.5 years (weighted average of present results and those reported in reference 1), $1.15\pm0.5\times10^4$ years, and $4.0\pm0.6\times10^3$ years, respectively.

THE alpha half-lives of Cm^{244}, Cm^{245}, and Cm^{246} have been determined by a technique which depends on the growth of the plutonium daughters from a curium sample of known isotopic composition. The decays involved in this experiment are

$$Cm^{242} \xrightarrow[162.5\ \text{day}]{\alpha} Pu^{238} \xrightarrow[90\ \text{yr}]{\alpha}, \quad (1)$$

$$Cm^{244} \xrightarrow[}{\alpha} Pu^{240} \xrightarrow[6580\ \text{yr}]{\alpha}, \quad (2)$$

$$Cm^{245} \xrightarrow[}{\alpha} Pu^{241} \xrightarrow[13\ \text{yr}]{\beta^-}, \quad (3)$$

$$Cm^{246} \xrightarrow[}{\alpha} Pu^{242} \xrightarrow[\sim5\times10^5\ \text{yr}]{\alpha}. \quad (4)$$

The curium, produced by the irradiation of plutonium 239 in the Materials Testing Reactor (MTR), was initially chemically separated from plutonium by anion and cation resin columns.[1] After a two week interval, the plutonium daughters were separated from their curium parents. This plutonium sample was analyzed in a 12-inch, 60° mass spectrometer with multiple filament surface ionization source.[2] The possibility of nonradiogenic plutonium contamination of the curium at the beginning of the first growth period necessitated a second growth period of the plutonium daughters and their separation from the curium. The isotopic composition of this second plutonium sample measured in the same mass spectrometer is given in column 4 of Table I. Column 2 of Table I gives the mole percent of each curium isotope in the parent curium sample. Since the time necessary to complete the experiments was short in comparison to the half-lives involved (a correction was made in the mole percent of Cm^{242} due to decay) the following type expression can be written for the unknown half-lives.

$$T_{\frac{1}{2}}(Cm^{244}) = T_{\frac{1}{2}}(Cm^{242}) \frac{\text{mole percent } Cm^{244}}{\text{mole percent } Cm^{242}} \times \frac{\text{mole percent } Pu^{238}}{\text{mole percent } Pu^{240}}. \quad (5)$$

Substituting in Eq. (5), the values obtained from the mass spectrometer for the curium and plutonium isotopic ratios and the value of 162.5 days[3] for the Cm^{242} half-life gives a value of 17.9±0.5 years for the Cm^{244} half-life. Since the Cm^{242} isotopic content depends on a decay correction, the alpha half-lives of Cm^{245} and Cm^{246} are calculated relative to the alpha half-life of 18.4 years for Cm^{244} (this is a weighted average of the 17.9 years and earlier values reported in reference 1). Using an equation similar to Eq. (5), the calculated half-lives of Cm^{245} and Cm^{246} are $1.15\pm0.5\times10^4$ years and $4.0\pm0.6\times10^3$ years, respectively.

The amount of Pu^{242} formed by electron capture of Am^{242} [see footnotes (b) and (c) of Table I; this americium is 99.95 mole percent Am^{243}] is negligible compared to that formed by Cm^{246} alpha decay.

TABLE I. Mass spectrometric analyses in mole percent of a curium sample and its plutonium daughters.

Curium isotope	Mole percent[a]	Plutonium isotope	Mole percent
$_{96}Cm^{242}$	1.52 ±0.04	$_{94}Pu^{238}$	38.9 ±0.3
$_{96}Cm^{243}$	...[b]	$_{94}Pu^{239}$[c]	0.132 ±0.005
$_{96}Cm^{244}$	95.83 ±0.07	$_{94}Pu^{240}$	61.0 ±0.3
$_{96}Cm^{245}$	1.27 ±0.04	$_{94}Pu^{241}$	0.0013±0.0005
$_{96}Cm^{246}$	1.36 ±0.04	$_{94}Pu^{242}$	0.0040±0.0005
$_{96}Cm^{247}$	0.016±0.002		

[a] These data are the same as those published previously (reference 1) with a correction due to the Cm^{242} decay.
[b] Cm^{243} was not determined due to Am^{243} impurity in the curium.
[c] The presence of Pu^{239} is partially accounted for by the reactions

$$Am^{243} \xrightarrow{\alpha} Np^{239} \xrightarrow{\beta^-} Pu^{239}.$$

[1] Stevens, Studier, Fields, Mech, Sellers, Friedman, Diamond, and Huizenga, Phys. Rev. **94**, 1083 (1954).
[2] M. G. Inghram and W. A. Chupka, Rev. Sci. Instr. **24**, 518 (1953).
[3] Hanna, Harvey, and Moss, Phys. Rev. **78**, 617 (1950).