Radionuclides and the Nuclear Fuel Cycle

RADIOCHEMICAL TECHNIQUES USED TO MEASURE THE CROSS SECTIONS LEADING TO THE PRODUCTION OF $^{242}$Cm AND $^{244}$Cm IN $^{241}$Am AND $^{243}$Am SAMPLES IRRADIATED IN THE ZEBRA REACTOR AT WINFRITH

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(Received February 23, 1981)

The integral production cross sections of $^{242}$Cm and $^{244}$Cm from irradiated samples of $^{241}$Am and $^{243}$Am have been measured, using the sensitive radiochemical techniques of alpha counting and alpha spectroscopy. The ion exchange procedures used to separate the curium produced in americium samples, following irradiation in the simulated P.F.R. and C.F.R. type neutron energy spectra available in the ZEBRA reactor, are described. The measured production cross sections are compared with theoretical predictions.

Introduction

The ability to accurately predict the higher actinide content of irradiated fast reactor fuel is important. The spontaneously fissioning nuclides $^{242}$Cm and $^{244}$Cm are of particular interest because their consequent fission neutrons may possibly lead to shielding problems when handling spent reactor fuel, and to operational difficulties on reactor shut down. The prediction of the likely inventory of curium isotopes in irradiated fuel is usually based on theoretical models; these calculated predictions may be subject to errors introduced by uncertain nuclear data, such as branching ratios, and are also very dependent on the accurate application of differential cross section data. There is, therefore, a need for experimentally determined integral cross section data, to check calculated production rates.$^{1-3}$

This paper discusses the radiochemical techniques adopted to measure the integral capture cross sections for $^{241}$Am leading to $^{242}$Cm and $^{243}$Am leading to $^{244}$Cm, following irradiation of small americium samples in the ZEBRA reactor at A.E.E. Winfrith (Figs 1 and 2). The neutron energy spectrum in the core of the ZEBRA is a close simulation of that in a fast reactor.
The curium produced in the irradiated americium samples has been separated and purified using ion exchange methods and has been qualitatively and quantitatively measured using alpha spectroscopy and gross alpha counting techniques.

**Experimental**

*Irradiation*

Triplicate oxide samples of approximately 10 mgs $^{241}$Am and 20 mgs $^{243}$Am were sealed in aluminium ampoules and inserted in aluminium plates of standard ZEBRA dimensions for incorporation within the lattice cell in place of sodium plates. Samples were irradiated in neutron energy spectra similar to both C.F.R. and P.F.R. type fast reactor cores.

The neutron fluence was monitored using absolute $^{239}$Pu fission chambers; the ratio of fluence between sample position and fission chamber positions was determined experimentally. The fluence delivered to the samples over the period of irradiation amounted to between $2.9 \cdot 10^{14}$ and $2.6 \cdot 10^{15}$ n·cm$^{-2}$.4