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SLOW NEUTRON FISSION OF Am242, Am242m, and Am243

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K. Street, Jr., A. Ghiorso, and S. G. Thompson

March 15, 1951

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SLOW NEUTRON FISSION OF Am^{242}, Am^{242m}, AND Am^{243}

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March 15, 1951

This letter is to report the pertinent results of some work done at scattered intervals during the years 1947 to 1949 and which may now be published. Independent measurements of the same cross sections by a Canadian team[1] gave somewhat different results.

Shortly after the discovery[2] of Am^{242} in a sample of Am^{241} irradiated with pile neutrons, it became apparent that this nuclide had a large destruction cross section. In a second Am^{241} irradiation of three times the intensity of the first, only 1.4 times as much Am^{242} was formed as determined[3] by counting the beta particles of Am^{242}. This ratio gave a destruction cross section for Am^{242} of approximately 10^4 barns. (This result is very insensitive to the cross section for the formation of Am^{242} as long as it is much less than 10^4 barns.) That this destruction was at least partially due to neutron capture to form Am^{243} became apparent with the discovery of this nuclide.[3]

When a mass spectrographic analysis of this second americium sample became available in December, 1949, it was possible to estimate the distribution of the destruction cross section of Am^{242} between fission and neutron capture to form Am^{243}. The composition of the americium was shown to be Am^{241} (99 percent), Am^{242} (0.5 percent), and Am^{243} (0.5 percent). From these data one calculates the following approximate cross sections: cross section for the formation of Am^{242}, ~50 barns; neutron capture cross section of Am^{242} to form Am^{243}, ~2000 barns; and total cross section for the destruction of Am^{242}, ~8000 barns. Thus the fission cross section of Am^{242} must be ~6000 barns. The estimate of 2000 barns for cross section of the reaction $Am^{242}(n,\gamma)Am^{243}$ is somewhat smaller than a previous estimate[3] and is still subject to large errors. The principal uncertainties are in the estimation of the neutron flux.

In 1949 the fissionability of americium samples containing various amounts of the nuclides Am^{242} and Am^{243} was measured with a fission counter[4] in the thermal neutron column of the Argonne heavy water pile. Measurements on americium of the composition given above gave a fission cross section for Am^{242} of about 6000 barns in agreement with the value obtained above. The measured fissionability was corrected for the Am^{241} present ($\sigma_{fission}$ 3.0 barns).[1,5] The fact that the Am^{243} present contributes a completely negligible amount to the observed fission was demonstrated by measuring an americium sample containing very nearly the same amount of Am^{242} and more than ten times as much Am^{243}. The observed fissionability in this sample was accounted for by the Am^{242} and allows a limit of less than 40 barns to be set on the fission cross section of Am^{243}.

The recent observation of the isomeric transition from the 16 hour Am^{242m} to the ground state[6] makes it seem likely that the Am^{242} observed in these samples came mainly through the formation of Am^{242m} and its subsequent decay to the ground state. Taking the branching of 20 percent given by O'Kelley et al.[6] and a cross section of ~300 barns[7] for the formation of Am^{242m}, the apparent cross section for the formation of Am^{242} in long irradiations (i.e., >>16 hours) is about 60 barns in fair agreement with that calculated from the isotopic abundances.

Some old measurements from this laboratory on the fissionability of Am^{242m} should be reinterpreted in the light of the isomeric transition to the highly fissionable Am^{242}. In this old work it was found that the fissionability of a sample of Am^{241} containing 50 parts per million of Am^{242m} (the amount of Am^{242m} was determined by counting the Cm^{242} which grew in and has been corrected for 60 percent beta decay branching)[6] decayed with a 16 hour half-life to the extent of 2.1 percent. Using these data and taking the fission cross section of Am^{241} as 3.0 barns, the fission cross section of Am^{242} as 6000 barns, and the branching decay of Am^{242m} by isomeric transition as 20 percent, one obtains a fission cross section for Am^{242m} of about 2000 barns. Again this value is subject to large errors.

We would like to express our appreciation to W. H. Zinn for the use of facilities at the Argonne National Laboratory for making the fission measurements. This work was performed under the auspices of the AEC.

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[1]Hanna, Harvey, Moss, and Tunnicliffe, Phys. Rev., to be published.

[2]Seaborg, James, and Morgan, National Nuclear Energy Series, Plutonium Project Record, Vol. 14B, "The Transuranium Elements: Research Papers," Paper No. 22.1 (McGraw-Hill Book Co., Inc., New York, 1949).

[3]Street, Ghiorso, and Seaborg, Phys. Rev. 79, 530 (1950).

[4]A. Ghiorso and W. C. Bentley, National Nuclear Energy Series, Plutonium Project Record, Vol. 14B, "The Transuranium Elements: Research Papers," Paper No. 22.29 (McGraw-Hill Book Co., Inc., New York, 1949).

[5]B. B. Cunningham and A. Ghiorso, "Thermal Neutron Fission of Am^{241}," Phys. Rev., in press.

[6]O'Kelley, Barton, Crane, and Perlman, Phys. Rev. 80, 293 (1950).

[7]obtained from an observed cross section of 200 barns for the formation of Cm^{242} and 60 percent beta decay branching of Am^{242m}.