^{241}Am (n, 2n) Cross-Section Measurements at 14.8 MeV Neutrons

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Abstract: The measurement of the cross section of the reaction ^{241}Am(n,2n)^{240}Am at 14.8 MeV neutrons, has been performed by the activation method. The neutron beam was produced at the Cock-croft Accelerator in China Institute of Atomic Energy, by the ^{3}H(d,n) ^{4}He reaction, using a Ti-tritiated target. The radioactive target consisted of a 201MBq ^{241}Am solution enclosed in a polypropylene tube. A natural Au solution containing about 1 mg Au, was mixed with ^{241}Am solution as reference materials for the neutron flux determination. After the end of the irradiation, the samples were placed into lead shield tube. The activity induced at the ^{241}Am target and the reference materials Au, was measured off-line by a well-type HPGe detector whose efficiency was calibrated by ^{240}Am and ^{241}Am activity standard source.

Keywords: Americium-241, Aurum-197, activation, cross sections, HPGe

Accurate neutron-induced reaction cross-section data are required for many practical applications, especially to predict reliably the behavior of reactor cores in both present and future fission reactors. Because the nucleus ^{241}Am is one of the most abundant isotopes in spent nuclear fuel[1], as well as one of the most highly radiotoxic of all actinides, accurate data are required to study the possible transmutation of long-lived Radioactive waste with advanced high-neutron-energy reactors. Theoretical predictions and evaluations (see Fig. 1.), differ in some energy regions by more than an order of magnitude[2], so it is necessary that cross sections of ^{241}Am(n,2n)^{240}Am are accurately measured. In this work, the cross section of the reaction ^{241}Am (n ,2n)^{240}Am has been determined at 14.8 MeV, by the activation method.

The measurements were carried out at the Cock-croft Accelerator in China Institute of Atomic Energy. The neutron beams were produced by the ^{3}H(d,n) ^{4}He reaction at a flux of the order of 10^{8} n/(cm^{2}·sec). The 300 μA deuteron beam enters through a 0.5 mm Mo foil into Ti-tritiated target. The absolute flux of the beam was obtained with respect to the ^{197}Au(n,2n)^{196}Au reference reactions were also taken into account. The variation of the neutron beam was monitored by the associated particle method for the T(d,n)^{4}He reaction was used. The Au-Si detector was used to detect ^{4}He particles.

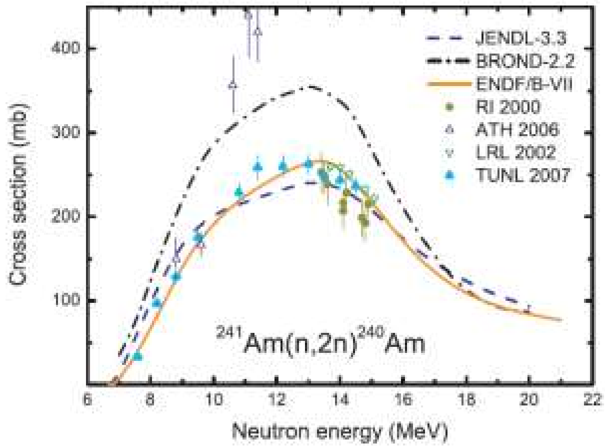

FIG. 1. Theoretical predictions and evaluations of cross sections of ^{241}Am(n,2n)^{240} Am[2].

The measurements were carried out at the Cock-croft Accelerator in China Institute of Atomic Energy. The neutron beams were produced by the ^{3}H(d,n) ^{4}He reaction at a flux of the order of 10^{8} n/(cm^{2}·sec). The 300 μA deuteron beam enters through a 0.5 mm Mo foil into Ti-tritiated target. The absolute flux of the beam was obtained with respect to the ^{197}Au(n,2n)^{196}Au reference reactions were also taken into account. The variation of the neutron beam was monitored by the associated particle method for the T(d,n)^{4}He reaction was used. The Au-Si detector was used to detect ^{4}He particles.

The Americium target consisted of a 201 MBq ^{241}Am source in the form of solution, encapsulated in polypropylene tube. A natural Au solution, containing about 1 mg Au, was mixed with ^{241}Am solution as reference materials for the neutron flux determination. The samples were irradiated at 0^{0}, at a distance of 1 cm from the center of the cell. A schematic representation of the experimental arrangement is shown in Fig. 2. Monte-Carlo calculation has been also employed to determine the energy and flux distribution of neutrons on each sample, and the contribution of scattered neutrons.

FIG. 2. A schematic representation of the experimental arrangement.

After the 9.5 h irradiation, the samples were placed into lead shield tube (seen in FIG.3) and transferred to the gamma spectroscopy system, based on a well-type HPGe detector. The activities of ^{240}Am and ^{196}Au in the sample were determined by using the counts in the full energy peak of the γ -ray transition. The efficiency of the HPGe detector was determined by ^{240}Am standard source. The γ -ray spectra of irradiated sample are shown in FIG.4.

FIG. 3. A photo of lead shield tubes and samples.

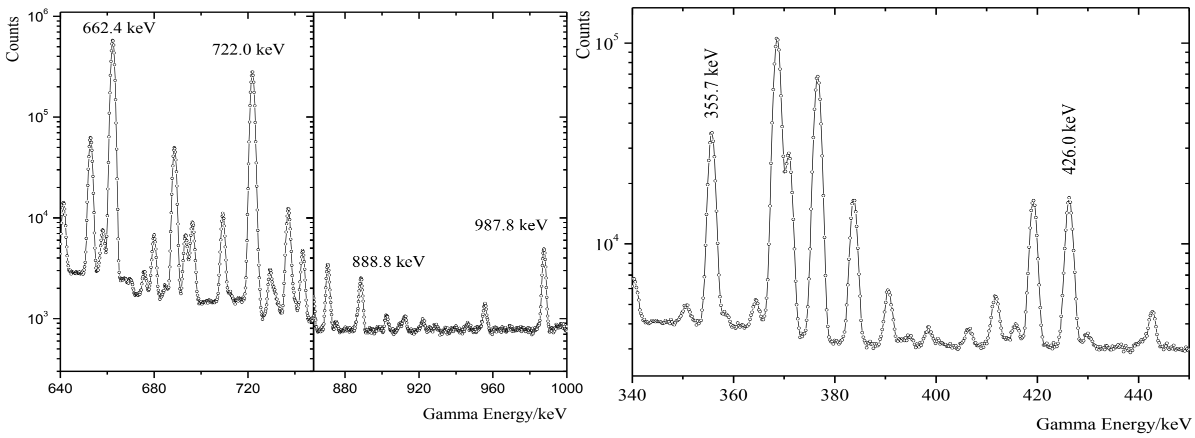

FIG. 4. The γ -ray spectra of irradiated sample for ^{241}Am/^{240}Am (left) and ^{196}Au (right).

The cross section of ^{241}Am($n,2n$) was calculated from the following activation formula:

$$\sigma_{\mathrm{Am}} = \frac{N_{240} N_{197} \lambda_{240} \left(1 - e^{-\lambda_{196} t}\right)}{N_{241} N_{196} \lambda_{196} \left(1 - e^{-\lambda_{240} t}\right)} \sigma_{\mathrm{Au}}$$

where σ_{Am} and σ_{Au} are the cross sections for the ^{241}Am(n,2n) and ^{197}Au($n,2n$) reactions, N_{240} and N_{196} are the atom number of ^{240}Am and ^{196}Au which are determined by the gamma spectroscopy system, N_{241} and N_{197} are the number of target nuclei of ^{241}Am and ^{197}Au, λ_{240} and λ_{196} are decay constant of ^{240}Am and ^{196}Au, t is irradiation time.

^{241}Am(n, 2n)^{240}Am cross section at E_n = 14.8 MeV is calculated. The result is 269(39) mb, which is in agreement with evaluations of ENDF/B-VII.1 (259 mb).

REFERENCES

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