Measurement of fast-neutron capture cross sections for ^{75}As

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Abstract The cross sections of the ^{75}As(n,γ)^{76}As reaction were measured in the neutron energy range from 0.50 to 1.50 MeV by using the activation technique. Neutrons were produced via the T(p,n)^{3}He reaction and the cross sections of the ^{197}Au(n,γ)^{198}Au reaction were used to determine the absolute neutron flux. Present results are compared with existing measurements and evaluations.

Keywords ^{75}As, Neutron capture cross sections, Activation method

CLC numbers O571.42$^+$1, O571.41$^+$3, O571.55$^+$2 A

1 INTRODUCTION

The cross sections of the ^{75}As(n,γ)^{76}As reaction are important in evaluating the radiation damage of the material. Experiments[1~6] and evaluations have been performed to determine the ^{75}As(n, γ)^{76}As reaction cross section, but there are large discrepancies among them especially in the MeV neutron energy region. Therefore, new experiment is needed.

2 EXPERIMENT DETAILS

The measurements were performed at the 4.5 MV Van de Graaff accelerator of the Institute of Heavy Ion Physics, Peking University. Nearly monoenergetic neutrons with energies of 0.5, 1.15 and 1.50 MeV were produced through the T(p,n)^{3}He reaction on a solid T-Ti target of 1.30 mg/cm^2 in thickness. The cross sections of the ^{197}Au(n,γ)^{198}Au reaction taken from the ENDF/B-VI library were used to determine the absolute neutron flux.

The arsenic samples made of natural As_2S_3 powder were pressed into disks of 19.1 mm in diameter, about 1 mm in thickness and about 1 g in weight. Each arsenic sample was sandwiched between two gold foils with the diameter of 19.1 mm and with the total weight of about 1 g. The sample groups were wrapped with cadmium foils of 0.5 mm in thickness.

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The samples were placed at 0^0 to the incident proton beam, and the distance from the sample to the target was about 2.2 cm. The irradiation durations for the three samples corresponding to 0.50, 1.15 and 1.50MeV were about 11, 15 and 23 hours, respectively. The proton energies after accelerating and before entering the T-Ti target were 1.427, 2.025 and 2.378 MeV, respectively. The proton beam current was about $10\mu A$. The neutron flux was monitored by a BF_3 long counter placed at 0^0 to the proton beam and at a distance of 3.0 m from the neutron source. For calculating the correction factor of the neutron flux fluctuation, the integral counts of the long counter per 2 minutes was recorded continuously by a microcomputer multiscalar.

After irradiation, the activities of the residual nuclei ^{76}Se (^{76}As β^- decay to ^{76}Se) and ^{198}Au were measured with an ORTEC HPGe γ-detector ($105\,cm^3$) calibrated by a set of standard γ-sources previously. The measuring duration for each arsenic and gold sample was about 20 minutes and 10 minutes to ensure statistics of counts better than 1%. The decay data of the residual nuclei including the half-life, γ-ray energy and γ transition intensity are taken from Ref.[7] and listed in Table 1. The two peaks corresponding to 559.10 and 563.23 keV γ-rays couldn't be separated, so we added them together during measurement and calculation.

Table 1 Decay data of the residual nuclei

Nuclei	$T_{1/2}$/d	E_γ/keV	I_γ/%
^{76}Se	1.0778	559.10, 563.23	45.0 1.2
^{198}Au	2.6943	411.80	95.57

3 CORRECTIONS

Two main corrections are described as follows.

3.1 γ-ray self-absorption in the sample

The correction factor of γ-ray self-absorption in the arsenic sample was measured by means of the γ-ray from the activated arsenic sample passed through a series of non-activted arsenic samples with different thickness. Values of the correction factor of γ-ray self-absorption in the arsenic are around 0.953, connecting with the thickness of the samples. The correction factor of γ-ray self-absorption in the gold sample was measured by using the 411.115 keV γ-ray of ^{152}Eu source instead of by using the 411.80 keV γ-ray of ^{198}Au and their values are around 0.986.

3.2 Cascade corrections

Because of the coincident of the 1228.6 and 657.0 keV γ-ray with the 559.10 keV γ-ray, the measured rate of 559.10 keV γ-ray will be a few percent lower than the corrected one. So a correction factor is needed. This correction factor for our measurement is 1.02, according to the decay scheme[7] and the efficiency curve of the HPGe detector.

4 RESULTS

After considering the detector efficiency, γ-intensity, correction factor from the fluctuation of the neutron flux, γ-ray self absorption in the samples and cascade correction, the cross sections of the ^{75}As(n,γ)^{76}As reaction were calculated by using the well known activation formula. The results of present experiment as well as the reference cross sections of the ^{197}Au(n,γ)^{198}Au reaction are listed in Table 2.

Table 2 Measured results and the reference cross section data

E_n/MeV	Cross section/mb	
	^{75}As(n,γ)^{76}As	^{197}Au(n,γ)^{198}Au
0.50±0.08	46.4± 2.4	132.4±4.6
1.15±0.08	18.2±1.1	75.4±3.4
1.50±0.08	13.4±0.8	67.6±3.0

Main sources of error for our measurement are given in Table 3. Errors from the decay scheme were ignored.

The results of our measurement and other measurements and evaluations are plotted in Fig.1. It can be seen that our results agree with the JENDL-3.2 evaluation. At 0.50 MeV our result is in good agreement with that of Macklin *et al.*[2] and At 1.15 and 1.50 MeV, our data are smaller than those of Johnsrud *et al.*[1], and much smaller than the ENDF/B-VI evaluation.

Table 3 Main sources of error and their magnitudes

Source of uncertainty	Relative error/%
Reference cross section	3.5~4.5
γ-counting statistics for ^{76}Se	1.0
γ-counting statistics for ^{198}Au	1.0
γ-detection efficiency for ^{76}Se	1.5
γ-detection efficiency for ^{198}Au	1.5
Correction of self absorption for ^{76}Se	1.0
Correction of self absorption for ^{198}Au	0.5
^{75}As sample weight	0.2
^{197}Au sample weight	0.2
Peak area determination	2.5
Total	5.1~5.9

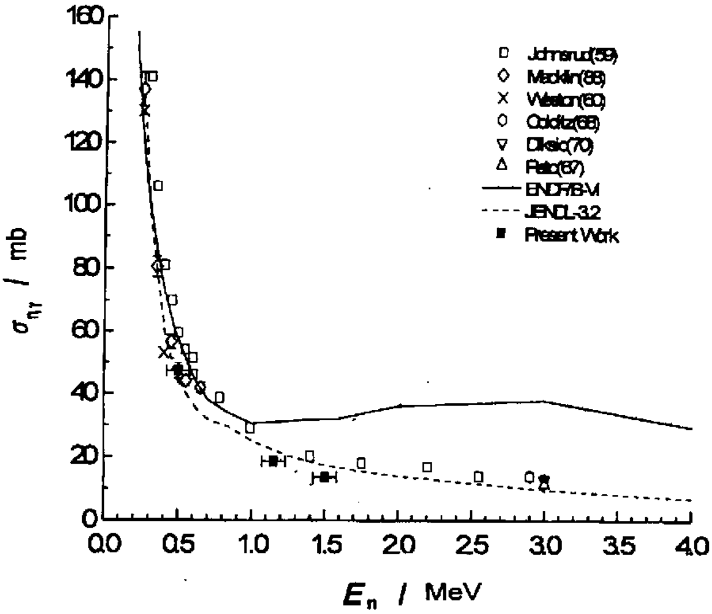

Fig.1 Comparison of the present measurement with other measurements and evaluations

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