Measurement of Cross Section for [114]Cd (n, 2n) [113m]Cd Reaction at 14 MeV

ZHU Xuebin[1]   ZHANG Feng[1, 2]   KONG Xiangzhong[1]

1. Department of Modern Physics, Lanzhou University, Lanzhou, 730001

2. School of Geosciences and Information, University of Petroleum, Dongyin

【 **abstract** 】 *The cross section of [114]Cd(n,2n)[113m]Cd reaction was measured relatively to [93]Nb(n,2n)[92m]Nb reaction at neutron energy of 14.7±0.3MeV, using the activation technique. The activities were measured with high resolution HPGe detector. The error of the measured cross section is 9.4%.*

Introduction

The neutron activation cross sections of 14 MeV are important for fusion study. Cadmium is an important material in a fusion reactor, but up to now, there are no data about the cross section for [114]Cd(n,2n)[113m]Cd reaction. In this work, the cross section for [114]Cd(n,2n)[113m]Cd reaction was measured by using the activation method at neutron energy of 14.7 MeV, using the [93]Nb(n, 2n)[92m]Nb reaction as a standard.

1   Measurement

The irradiation of sample was carried out at the ZF-300- II Intense Neutron Generator of Lanzhou University with the neutron yield about $(1\sim3)\times10^{12}$ s^{-1}. Neutrons were produced by T(d, n)^{4}He reaction with an effective deuteron beam energy of 125 keV and a beam current of 20 mA. The thickness of T-Ti target is 0.9 mg/cm^2. The neutron fluence was monitored with a uranium fission chamber so that the corrections could be made for variation of neutron yields during the irradiation. The samples were placed at the angle 0º relative to the beam direction and were irradiated for 17.97 h. The cross section of the reaction was determined relatively to the cross section of [93]Nb(n, 2n) [92m]Nb reaction. The samples were made of natural metal foils. The cadmium sample was 30 mm in diameter, 0.8 mm in thickness and 99.99% in chemical purity. The niobium sample was 30 mm in diameter, 0.9 mm in thickness and 99.9% in purity. The cadmium sample was sandwiched between two niobium foils. The neutron energy was 14.7±0.3 MeV determined by the method of cross section ratio of zirconium and niobium[1].

After irradiation, the cadmium sample was cooled for 10.89 a. The activities of [113m]Cd and [92m]Nb were measured by using a CH8403 coaxial high purity germanium detector with a relative efficiency of 20% and an energy resolution of 3 keV at 1.33 MeV. The efficiency of the detector was calibrated using the standard gamma source (SRM4275) from the National Institute of Standard and Technology, USA[2]. The error of the absolute efficiency was estimated to be 2%. The decay data used in this study are taken from Ref. [3] and listed in Table 1.

Table 1   Decay data of products

α/%	Reaction	$T_{1/2}$	E_γ/ keV	I_γ / %
28.73	[114]Cd(n, 2n) [113m]Cd	14.1 a	263.7	0.023
100	[93]Nb(n, 2n) [92m]Nb	10.15 d	934.5	99.2

α: Abundance of target isotope

In the measurement of gamma-ray activities, some corrections were made for the effects of neutron intensity fluctuation, gamma-ray self-absorption in the samples, the sum peak effects in the investigated nuclide and the counting geometry, etc.

2   Results

The cross section was calculated by the following formula:

$$\sigma_x = \frac{[S\varepsilon I_\gamma \eta KMD]_o [\lambda AFC]_x}{[S\varepsilon I_\gamma \eta KMD]_x [\lambda AFC]_o} \sigma_o$$

Where σ_x, σ_o are the measured and standard cross-

sections, respectively; ε is full energy peak efficiency of the measured characteristic gamma ray; I_γ is gamma-ray intensity; η is abundance of the target nuclide; M is mass of sample; $D = e^{-\lambda t_1} + e^{-\lambda t_2}$ is counting correction factor (where t_1, t_2 are time intervals from the end of the irradiation to the start and finish of counting, respectively); A is atomic weight; C is measured full-energy peak area; $F = f_s f_c f_g$ is total correction factor of the activity (where f_s, f_c and f_g are the correction factors for the self-absorption in the sample for a given gamma energy and the sum effect of cascade gamma rays in the investigated nuclide as well as the counting geometry, respectively); and K is neutron fluctuation factor.

$$K = \sum_{i=1}^{L} [\Phi_i (1 - e^{-\lambda \Delta t_i}) e^{-\lambda T_i}] / (\Phi s)$$

Where L is number of time intervals, into which the irradiation time is divided; Δt_i is duration of the ith irradiation time; λ is decay constant; T_i is time interval from the end of the Δt_i to the end of irradiation; Φ_i is neutron fluence averaged over the sample in Δt_i; Φ is neutron fluence averaged over the sample in the total irradiation time T, S is factor $1 - e^{-\lambda T}$.

The measured cross section for the ^{114}Cd(n, 2n) ^{113m}Cd reaction in this work is shown in Table 2.

Table 2　The measured cross sections

Reaction	E_n / MeV	σ / mb
^{114}Cd(n, 2n) ^{113m}Cd	14.7$\pm$0.3	432$\pm$41
^{93}Nb(n, 2n) ^{92m}Nb	14.7$\pm$0.3	458.2$\pm$9.2

The errors reported in this work are from counting statistics, standard cross section, detector efficiency, neutron energy, weight of samples, self-absorption of gamma ray, etc.

Reference

[1] QIU Jiuzi et al., Journal of Lanzhou University (Natu Sci), 1995, 31(4): 118

[2] WANG Yongchang et al., High Energy Phys & Nucl Phys. 1990, 14(10): 923

[3] R.B Firestone, Table of Isotopes, 8th edition, 1996

Measurement of Thermal Neutron Capture Cross Section

HUANG Xiaolong　HAN Xiaogang　YU Weixiang　LU Hanlin　ZHAO Wenrong

China Institute of Atomic Energy, P.O.Box 275(41) Beijing,102413

e-mail huangxl@iris.ciae.ac.cn

【abstract】 *The thermal neutron capture cross sections of ^{71}Ga(n,γ)^{72}Ga, ^{94}Zr(n,γ)^{95}Zr and ^{191}Ir(n,γ)^{192}Ir$^{m1+g,m2}$ reactions were measured by using activation method and compared with other measured data. Meanwhile the half-life of ^{72}Ga was also measured. The samples were irradiated with the neutron in the thermal column of heavy water reactor of China Institute of Atomic Energy. The activities of the reaction products were measured by well-calibrated Ge(Li) detector.*

Introduction

The thermal neutron capture cross sections of ^{71}Ga(n,γ)^{72}Ga, ^{94}Zr(n,γ)^{95}Zr and ^{191}Ir(n,γ)^{192}Ir$^{m1+g,m2}$ reactions are very important for evaluating the radiation damage of the material, especially for the metal Ir.

The very accurate capture cross section is needed for Ir metal due to its larger capture cross section and longer half-life($T_{1/2}$=241 a). All measurements of other laboratories were performed before 1978, and there are large discrepancies among them. So new measurements are needed.