Measurement of ^{232}Th(n,g) reaction cross-section at the neutron energy 5.09 MeV

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Introduction

There is current interest worldwide to develop new concepts of nuclear power generation and major efforts are on to realize this. Among them, accelerator driven sub-critical system (ADSs), fast reactor, compact and high temperature reactors and advanced heavy water reactor (AHWR) are the most important for power production. For the design of such reactors, nuclear data for reaction and fission cross-section of structural and cladding material and fuel elements as well as yields of fission products produced in neutron induced fission of the relevant actinides with medium to fast neutron energies are important.

From India's perspective, which has abundant reserves of thorium, ADSs is relevant because one can also exploit its potential to design hybrid reactor systems that can produce nuclear power with the use of thorium as the main fuel. ADSs can enable one to design reactor system which primarily burn thorium fuel as well as make a more efficient use of uranium fuel [1].

In the present work, we determine the^{232}Th(n,γ) reaction cross-section at the neutron energy of 5.09 MeV by using the off-line γ-ray spectrometric technique. The present experimental data at 1.12 MeV is compared with the literature data at other neutron energies.

Current Status of present work

An examination of International Atomic Energy Agency-Exchange Format (IAEA-EXFOR) database shows that a significant discrepancy exits in the measured experimental data for many neutron threshold reactions in MeV region and at thermal energies. Furthermore, literatures available in IAEA-EXFOR database show that most of the thermal neutron activation cross-sections were made in reactors with neutron spectra and therefore these data are not precise thermal cross-section measurements [2].

The detailed literature survey on fission yield and cross-section measurements related to Th-U and U-Pu fuel cycles show that the exhaustive experimental work has been carried out in low energy neutron induced fission of actinides [3-4]. However, experimental data in medium to high energy neutron induced fission of actinides, which has immense importance for the design of advanced reactors and ADSs are rare and very much limited [5].

Experimental Details

The experiment was carried out using the 14UD BARC-TIFR Pelletron facility at Mumbai, India. The neutron beam was obtained from the ^{7}Li(p, n) reaction. The energy spread for the proton at 6m was in the range 50–90 keV. Further, we use a collimator of 6mm diameter before the target. The size of the ^{232}Th metal foil was 1.0×0.7 cm^{2} and weight of 0.1911gm, whereas the indium metal foil was also of the same size and weight was 0.1239gm. The γ-ray activity of ^{115m}In from the ^{115}In(n,n')^{115m}In and fission monitor reactions were used to measure the neutron flux. The isotopic abundance of ^{115}In in natural indium is 95.7%. The Ta-Li-Ta and Th-In stacks were irradiated for 11.25 hours. The proton beam energy was 7MeV. The proton current during the irradiations was 110 nA. After irradiation, the samples were cooled for one

875hours 38min. Then, the irradiated target of Th and In along with the Al wrapper were mounted in two different perspex plates and taken for γ-ray spectrometry. The γ-rays of fission/reaction products from the irradiated Th and In samples were counted in an energy- and efficiency-calibrated 80 c.c. HPGe detector coupled to a PC-based 4K channel analyzer.

Calculations

From the photo-peak activity of 312 keV γ-ray of ^{233}Pa, the ^{232}Th(n,γ) reaction cross-section (σ) was calculated by using the usual decay equation [6]. The ^{115}In(n,γ)^{116m}In and fission monitor were used as the neutron flux monitor [7].

Results and Discussion

^{232}Th(n,γ) reaction cross-section obtained from the present work at the neutron energies of 5.09 MeV is shown in Table. The ^{232}Th(n,γ) reaction cross-section at average neutron energy of 5.09 MeV in the present work is determined for the first time and it falls well within the range of available experimental as well as theoretical data as shown in the graph below.

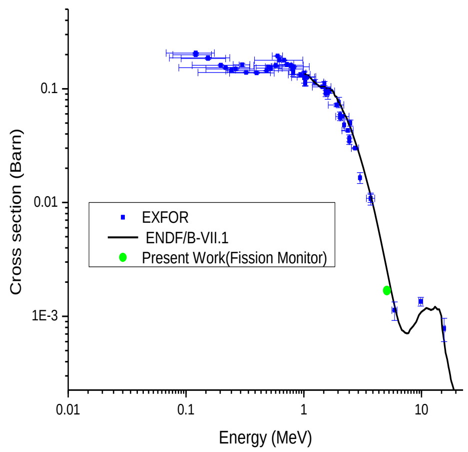

Fig. Comparison of present experimental ^{232}Th(n,γ) reaction cross-section with the EXFOR and ENDF data.

$^{97}_{40}Zr\ (n,\gamma)^{97m}_{41}Nb$ Fission Monitor		$^{232}_{90}Th\ (n,\gamma)^{232}_{90}Th$
E_n MeV	**Flux (n/cm^{2}s)**	**Cross Section (barn)**
		Present Work
5.09	2.06E+06	0.00168± 6.75081E-05

Table: Present experimental data

References

[1] S.S. Kapoor, Pramana-J.Phys. **59**, 941 (2002)
[2] IAEA-EXFOR Data base, at http://www.nds.iaea.org/exfor
[3] H. Naik, et al., Eur. Phys. J. **A47**, 51 (2011)
[4] S. A. Chitamber, H. C. Jain, M.V. Ramamiah, Radiochem. Acta. **42**, 169 (1987)
[5] T. R. England and B. F. Rider, Evaluation and Compilation of fission Products Yields, ENDF/BV1 (1989)
[6] V. Vansola et al. Radiochimica Acta **103** (12), 817–823 (2015)
[7] NuDat 2.6, National Nuclear Data Center, Brookhaven National Laboratory, available at http://www.nndc.bnl.gov/