The excitation function for ^{93}Nb(n, α)^{90}Y^{m} reaction (i) measured over 13.73MeV to 14.77MeV neutron energies and (ii) calculated over 10MeV to 20MeV neutron energies.

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Introduction

The data of the cross-sections of nuclear reactions induced by neutrons of different energies are important for nuclear science and technology. The variations in the cross-sections with neutron energy are also of great interest for studying the excitation of nuclei to different energy levels and subsequent decay to ground state. The probability of exciting a nuclei to the energy levels higher than the metastable state are of interest because the metastable state can be populated through the decay process. The cross-section for formation of metastable state of nuclei therefore increases with incident neutron energy.

The measured cross-section data for (n, α) reaction is of relevance to applied issue such as helium gas production through reactions with elements such as niobium which is used as a first wall and structural material in the experimental fusion reactors. In the present work, the cross-sections for formation of ^{93}Nb(n, α)^{90}Y^{m} reaction have been measured at five different neutron energies and also estimated theoretically using EMPIRE-II and TALYS codes from 10MeV to 20MeV neutron energy.

Experimental

The neutron generator system of the University of Pune was used in which neutrons are produced through the D-T reaction. In this experiment 175keV deuterium ions were bombarded on a tritium target of 8 Curie activity at normal incidence. The neutrons emitted at 0^0, 30^0, 60^0, 90^0 and 120^0 with reference to the incident deuteron beam had energies 14.77MeV, 14.68MeV, 14.42MeV, 14.07MeV and 13.73MeV respectively. At each sample position, the neutron flux measured with the activation technique was found to be uniform ~$5x10^7$n/cm^2-S.

For this work, elemental niobium in the form of Nb_2O_5 was used. The ^{27}Al(n, α)^{24}Na reaction was chosen as monitor reaction in which pure aluminum foil was used. Each sample was made by packing 1gm of niobium powder and 0.2gm aluminum foil. Such five samples were prepared for this experiment. A plexiglass plate was mounted horizontally in front of the tritium target holder, with the centre coinciding with the tritium target centre. On this plate angle positions were marked and the five samples were mounted at a distance of 50mm from the tritium target. These samples were irradiated with neutrons for a period of 50 minutes simultaneously. At the end of the irradiation period, the 14MeV neutron generator was switched off and all the five irradiated samples were brought to the counting room for measuring the induced gamma-ray activities. The induced gamma ray activities of each irradiated sample were measured for a period of 30 minutes using an HPGe detector sequentially. The cross-sections for the formation of metastable state were estimated using the activation formula and employing relative method.

Results and Discussion

The measured gamma-ray spectra of the $^{90}Y^{m}$ and ^{24}Na produced in the sample at 13.73MeV neutron energy are shown in Fig.1. The excitation function for $^{93}Nb(n, \alpha)^{90}Y^{m}$ reaction (i) measured over 13.73MeV to 14.77MeV neutron energies and (ii) calculated over 10MeV to 20MeV neutron energies in the present work are shown in Fig.2 along with a few literature values. The cross-sections measured in the present work vary from 5mb to 7.2mb over 13.73MeV to 14.77MeV neutron energies. The measured cross-sections over 13.73MeV to 14.68MeV neutron energy range are in agreement with the theoretical cross-sections estimated using Empire-II code. However, the measured cross-section at 14.77MeV is in agreement with the theoretical cross-section estimated by Talys code. From the theoretical calculation it was found that the cross-section of this reaction decreases above 17MeV neutron energy mainly due to the initiation of (n, α+2n) and (n, α+2p) reactions. Moreover, the cross-sections measured by Filatenkov and Ikeda as shown in Fig.2 are found close to the values obtained using EMPIRE-II code, whereas, cross-sections measured by Molla are close to those obtained using TALYS. It is also observed in Fig.2 that the cross-sections measured by Fessler below 17.72MeV neutron energy are lower whereas above 20MeV neutron energy it is found to be higher than those obtained theoretically.

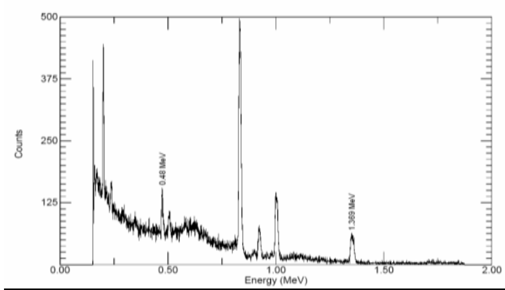

Figure-1: Gamma-ray spectrum of $^{90}Y^{m}$ and ^{24}Na radioisotopes.

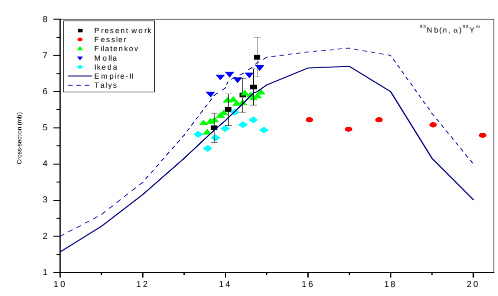

Figure-2: Excitation function of $^{93}Nb(n, \alpha)^{90}Y^{m}$ reaction.

References

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