Complete Fusion in ^{9}Be + ^{159}Tb at near barrier energies

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Introduction

The heavy ion fusion near the Coulomb barrier is one of the probes to study tunneling phenomena under different circumstances. The fusion cross section above the barrier can be reproduced by a single barrier penetration model [1], while measured cross sections below the barrier are enhanced as compared to the calculation. Reactions with weakly bound nuclei are of particular interest, where the low binding energies of these nuclei have a significant effect on different reaction channels. In addition, since radioactive ion beams are found to exhibit unusual features such as extended shapes and large breakup probabilities, study of reactions involving weakly bound stable nuclei like ^{6,7}Li and ^{9}Be, have attracted much attention recently. Fusion reactions with ^{6,7}Li projectiles on ^{159}Tb target have been measured in the past [2]. In this paper we report excitation function measurement of ^{9}Be + ^{159}Tb.

Experimental details

The experiment was performed at Pelletron Linac Facility at TIFR, Mumbai. The self supporting ^{159}Tb foils (mass thickness $\sim$ 1.2 - 1.7 mg/cm^2) were bombarded with ^{9}Be beam of energy (E_{lab}) $\sim$ 30 MeV to 47 MeV. Aluminum catcher foils were mounted behind the target for catching recoiling residues. For effective utilization of the beam time, in few case " target-1 + catcher foil + degrader foil + target-2 + catcher foil " combinations were irradiated together. Hence the incident energy as well as the spread in the energy in each case were calculated using TRIM [3].

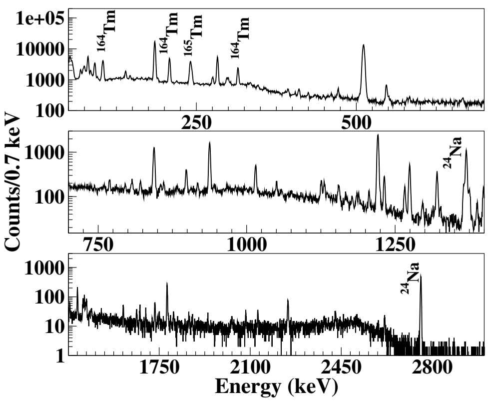

FIG. 1: An offline γ-ray spectrum for ^{9}Be + ^{159}Tb at E_{lab} = 44.6 MeV.

During the irradiation, beam current was recorded at regular intervals using CAMAC-based scaler. The activated samples were counted offline using three HPGe detectors and the data is acquired using N6724 14-bit, 100 MS/s digitizer. Detectors were shielded by 5 cm thick lead for reducing the ambient background. The analysis was done using C++ based root framework [4] and LAMPS [5]. The efficiency and calibration of detector was done using standard gamma-ray

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sources ^{152}Eu and ^{241}Am. One of the HPGe detector is with carbon fiber body (thickness $\sim$ 1.6 mm) was used to measure low energy γ-rays. The samples were counted at 10 cm as well as on the face of a detector (in close geometry). The efficiency for target on face was obtained by scaling method. The γ-ray spectrum of ^{159}Tb with E_{lab} = 44.6 MeV is shown in fig. 1. The cross section at respective energy were measured using characteristic γ-ray.

Data Analysis and Result

TABLE I: Observed residue in fusion and transfer channels.

Channel	Nuclide	$T_{1/2}$	E_γ (keV)	I_γ (%)
3n	^{165}Tm	30.6 h	242.9	35.3
4n	^{165}Tm	1.95 m	91.1	6.7
	^{165m}Tm	5.1 m	208.1	14.9
			314.9	9.6
Transfer	^{160}Tb	72 d	298.6	26.1
			879.4	30.1
			962.3	9.8
			966.2	25.1

Measured residues from the compound nuclear fusion in ^{9}Be + ^{159}Tb (V_b = 34.6 MeV) are listed in the table I. As ^{160}Tb (1n- stripping) had a very long half-life compared to other reaction products produced in the experiment, the irradiated samples were counted after 7 days to minimize target induced background (see fig. 2). For the unambiguous identification, half-life was tracked for most of the residues are consistent with literature. Details of residue cross-sections and fusion excitation measurements will be presented.

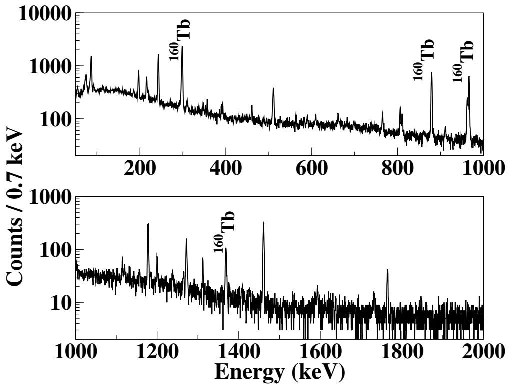

FIG. 2: The γ-ray spectrum of ^{9}Be + ^{159}Tb after $\sim$ 7 d, showing ^{160}Tb (1n stripping).

Acknowledgments

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