ER excitation function measurement for the ^{35,37}Cl+^{181}Ta reactions

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Introduction

The formation probability of a compound nucleus (CN) and its survival against fission decay are two important aspects in heavy ion fusion reactions, the only established route to super-heavy element synthesis, till date. The intricacies of fusion process and the microscopic stabilization of the CN or the evaporation residue (ER) against fission are not completely known. Though shell closure is speculated to enhance the survival probability by various theoretical formalisms, experimental data are rather scarce, particularly for the neutron shell closure at N=126.

The ER cross sections have been reported for the ^{32}S+^{184}W [1] and ^{32}S+^{182}W [2] reactions forming the CN ^{216,214}Th, with neutron numbers 126 and 124 respectively. Both these measurements were performed using the recoil mass spectrometers, former using the FMA at the Argonne National Laboratory and the latter using the JAERI-RMS. However, the measured ER cross sections for the two reactions show orders of magnitude difference (as shown in FIG. 1), though the CN produced differ only by two neutrons [3]. In order to explore this anomalous difference in ER cross sections, we started a series of ER measurements populating different isotopes of Th nuclei. Preliminary results of one set of ER measurements is reported here.

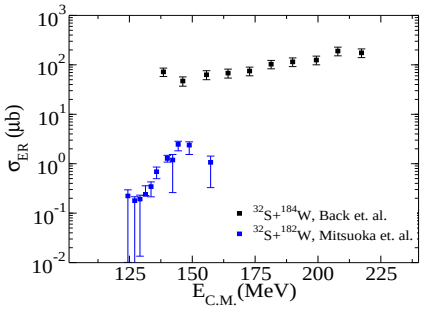

FIG. 1: ER cross section for ^{32}S+^{182,184}W reaction.

Experimental details

ER cross sections have been measured for the ^{35,37}Cl+^{181}Ta reactions in the energy range 169.7-235.9 MeV (for ^{35}Cl beam) and 170.3-236.6 MeV (for ^{37}Cl beam) at Inter University Accelerator Centre (IUAC), New Delhi. Pulsed ^{35,37}Cl beams with 2 μs pulse separation from the 15UD Pelletron accelerator were further boosted using the superconducting LINAC to bombard the 170 μg/cm^2

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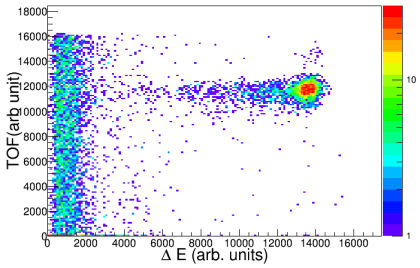

FIG. 2: The ΔE versus TOF spectrum of ^{35}Cl+^{181}Ta at 205.3 MeV beam energy.

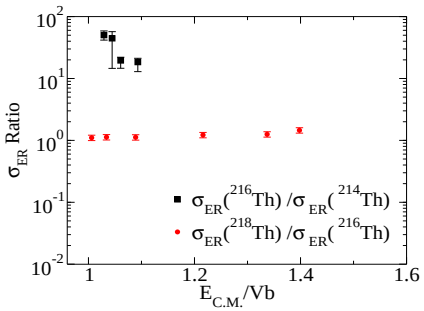

FIG. 3: Ratio of the total ER cross sections of ^{35,37}Cl+^{181}Ta reactions compared with that of ^{32}S+^{182,184}W reactions.

^{181}Ta (with 20 μg/cm^2 carbon backing) target in this experiment. The ERs produced in the reactions were separated using the HYbrid Recoil mass Analyzer (HYRA) [4]. Two silicon detectors were mounted at $\pm 25^0$ to record the Rutherford events, which were used for the cross section normalization. HYRA was operated at 0.15 Torr He gas pressure throughout the experiment. The focal plane detectors consisted of a position sensitive MWPC of active area 6 inch × 2 inch and a silicon strip detector of area 2.36 inch × 2.36 inch. A time-of-flight (TOF) signal was generated using the MWPC anode and RF signals for effective separation of ERs from other scattered particles reaching the focal plane. FIG.2 shows energy loss (ΔE) vs TOF spectrum for 205.3 MeV beam energy for the ^{35}Cl+^{181}Ta reaction.

Analysis and results

ER cross section (σ_{ER}) is calculated using the equation:

$$\sigma_{ER} = \frac{Y_{ER}}{Y_{mon}} \left(\frac{d\sigma}{d\Omega}\right)_R \Omega_M \frac{1}{\varepsilon_{HYRA}} \qquad (1)$$

where Y_{ER} is the ER yield at the focal plane detector, Y_{mon} is the yield in the monitor detector, ε_{HYRA} is the HYRA transmission efficiency and Ω_M is the solid angle subtended by the monitor detector. In this analysis, we used the ^{30}Si+^{186}W reaction for estimating the average ε_{HYRA}.

The ratio of total ER cross sections obtained for the two reactions populating ^{216,218}Th nuclei is compared with the ratio of ER cross sections reported for the ^{32}S+^{184}W and ^{32}S+^{182}W reactions in FIG. 3. While the reactions forming ^{214,216}Th nuclei using S beams showed an anomalous difference, no such difference could be seen in the present study which populated ^{216,218}Th, differing again by two neutrons. Our preliminary results do not support any possible stabilizing effects of shell closure in CN with N=126. Detailed analysis of the data and interpretation of the results are in progress.

Acknowledgments

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