Evaporation residue cross-section measurements for compound nuclei around Z_{CN}=82 region

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Introduction

For understanding the reaction mechanism involving heavy compound nuclei (CN), we have performed measurements of the evaporation residue (ER) cross-section for the (i)^{48}Ti+^{150}Nd→^{198}Pb, (ii)^{48}Ti+^{142}Nd→^{190}Pb and (iii)^{48}Ti+^{144}Sm→^{192}Po systems leading to CN around Z_{CN}=82 region. It is conjectured that proton shell closure Z_{CN}=82 may lead to enhanced ER production [1] and may help in the synthesis of heavy nuclei. Here, we investigate the effect of proton shell closure Z_{CN}=82 and deformation through the ER cross-section measurements.

The experiment was carried out in the gas-filled mode of HYbrid Recoil mass Analyzer (HYRA) [2] using 15 UD Pelletron+LINAC accelerator facility at IUAC, New Delhi. More details of the experimental set up is available in Ref. [3].

Experimental analysis

For the determination of ER cross-section, extraction of transmission efficiency plays a key role. For the efficiency measurement, ^{48}Ti+^{122}Sn was used as a calibration reaction. Using the already existing experimental ER cross-section [4] and the Monte Carlo simulation code TERS [5], experimentally extracted average transmission efficiency value for ^{48}Ti+^{122}Sn reaction is 28.71±5.6%. The efficiency value of the calibration reaction was further normalized for other systems to obtain the ER cross-section for ^{48}Ti+^{142,150}Nd, ^{144}Sm systems which are shown in Fig. 1.

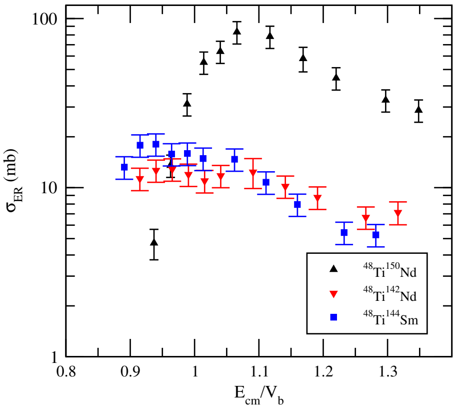

FIG. 1: ER cross-section for ^{48}Ti+^{142,150}Nd, ^{144}Sm systems as a function of E_{cm}/V_b.

Here, ER cross-section for deformed ^{150}Nd target (β_2=0.27) is higher in comparison to the spherical ^{142}Nd (β_2=0.09) and ^{144}Sm (β_2=0.087) targets.

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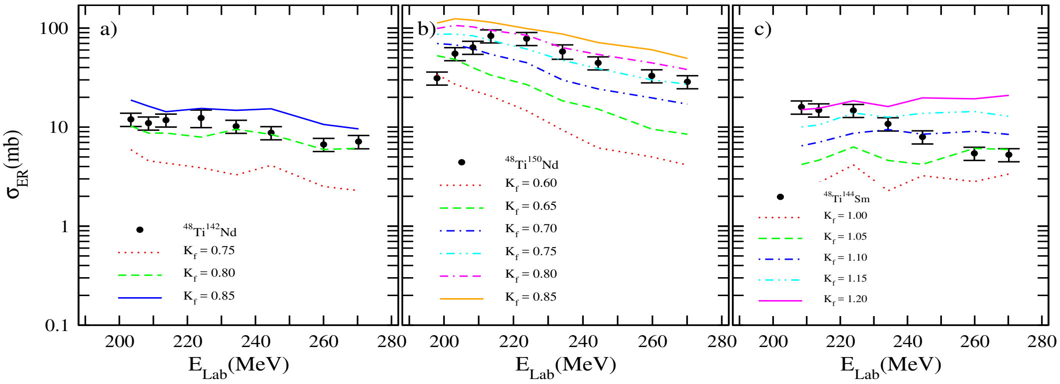

FIG. 2: Experimental ER cross-section (filled circle) versus energy in lab frame (E_{lab}) along with theoretical results obtained using statistical model calculations after varying K_f for a) ^{48}Ti+^{150}Nd b) ^{48}Ti+^{142}Nd and c) ^{48}Ti+^{144}Sm systems including shell-correction in the level density and fission barrier.

Theoretical calculations

Statistical model (SM) calculations are performed using Bohr-Wheeler (BW) formalism [6] for fission width (Γ_f) including shell correction in the level density and fission barrier. A scaling factor (K_f) for the FRLDM barrier is introduced and treated as an adjustable parameter to fit the experimental ER cross-sections. Coupled channel calculations were performed to obtain CN spin distributions from the CCFULL code [7] and used as an input in the SM code. SM calculations were subsequently performed and K_f was adjusted to reproduce the ER cross-sections in the measured energy range. The final theoretical cross-section values are compared with the experimental ones after varying K_f values are shown in Fig. 2. It is observed that a single value of K_f cannot fit the ER cross-sections over the entire range. For ^{142,150}Nd targets, K_f=0.80 and for ^{144}Sm K_f>1 gives fit to the ER cross-section. The smaller values of scaling factor corresponds to the higher contribution of non compound nuclear (NCN) processes. The results shows that quasi-fission (QF) is either absent or very small for ^{144}Sm target and it supports the earlier measurements mentioned in Ref. [8]. In case of Nd targets, smaller K_f signifies the contribution from QF.

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