Complete and incomplete fusion studies of evaporation residues populated in $^{12}C+^{154}Sm$ system

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Introduction

There has been a growing interest in the study of incomplete fusion (ICF) dynamics because of the complexity of the heavy ion (HI) induced reactions at lower projectile energy. Previous studies have shown that the ICF process significantly contributes to the total fusion cross-section in low energy regime. At low values of impact parameter, the projectile gets completely fused with the target nucleus and complete fusion (CF) occurs. In this process the complete transfer of linear and angular momenta takes place from projectile to target with the evolvement of an excited compound nucleus (CN) which further emits low energy evaporation nucleons followed by γ-rays to acquire its ground state. In contrast, ICF takes place with partial momentum transfer [1,2] and a part of the projectile fuses with the target while the rest part behaves as spectator.

The ICF of the incident projectile particle was first observed by Britt and Quinton [1]. After then this area of research got broadened in respect of various aspects like projectile energy and structure and various entrance channel parameters [3,4,5] namely mass asymmetry, coulomb factor and target deformation etc. An effort has been made to investigate the CF and ICF dynamics by measuring the excitation functions (EFs) of the evaporation residues (ERs) populated in the interaction of ^{12}C projectile and ^{154}Sm target at different beam energies between ≈5-8 MeV/A.

Experimental Procedure

The present experiment for the measurement of EFs of the residues populated in system $^{12}C+^{154}Sm$ was performed by our group at the Inter-University Accelerator Centre (IUAC), New Delhi, India. The target foils of ^{154}Sm (enrichment~98.69%) were prepared by vacuum evaporation technique. Eight target-catcher assemblies were set up for the purpose of carrying out experiment by using single projectile beam at different energies. Each ^{154}Sm target foil was backed by thick aluminium (Al) foils to catch the produced ERs. The foils of ^{154}Sm, with a thickness ≈ 250-650 μg/cm^2 were irradiated by beam of $^{12}C^{6+}$ in GPSC (General Purpose Scattering-Chamber) at IUAC, New Delhi. Target irradiation was done at a single energy. Multiple incident energies were achieved due to energy loss of ion beam while traversing through different foils. The offline stacked foil activation technique has been used to measure the EFs. The induced γ-ray activities in various target-catcher foils were recorded by counting them using pre-calibrated high purity germanium (HPGe) detectors, coupled to a CAMAC-based data acquisition system. Energy and efficiency calibration of the HPGe detectors was done by using standard ^{152}Eu γ–ray source. The obtained γ–ray spectra are analysed using the software CANDLE [6] and the residues populated in reaction are identified by characteristic γ–ray of respective ERs and decay curve analysis.

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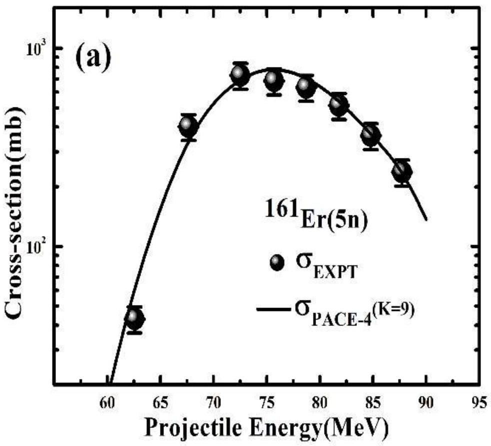
Analysis and result

In the present work three residues-^{161}Er(5n), ^{159}Er(7n) and ^{157}Dy(α5n) are found to be populated through CF and ICF dynamics. The excitation functions of the above-mentioned residues have been deduced from the γ-ray spectra and shown in Fig.1(a) and (b). The measured cross-sections of the populated residues are compared with the values obtained from statistical model code PACE-4 [7] at different energies. The value of 'K=9' has the best match with the measured values of cross-sections while comparing with PACE-4 [7], where $K = A/a$. Here, 'A'= Mass number of the excited CN, 'K' and 'a' are Level density parameter constant and Level density parameter, respectively. The PACE-4 [7] code is based on compound nucleus theory.



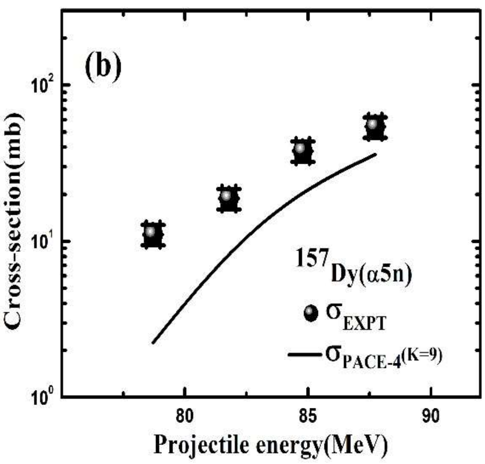


Fig. 1. Measured excitation functions along with their theoretical predictions of PACE-4 code for ERs (a) ^{161}Er(5n) and (b) ^{157}Dy(α5n) produced via CF and ICF in ^{12}C+^{154}Sm system.

In Fig. 1(a) the measured cross-sections of ^{161}Er(5n) are compared with the PACE-4 [7] cross-sections and found to be reproduced well. As such ER ^{161}Er(5n) has been produced via CF only, while measured cross-sections of ^{157}Dy(α5n) are found to be significantly enhanced from its PACE-4 (K=9) predictions, as shown in Fig. 1(b). This ER ^{157}Dy has been produced not only via CF, but also populated through ICF (i.e., break-up of ^{12}C in to α+^{8}Be). Further, analysis of measured data is going on for the system ^{12}C+^{154}Sm.

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