Measurement of angular distributions of evaporation residues populated through complete and incomplete fusion in ^{16}O + ^{146}Nd system

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Introduction

The study of the incomplete fusion (ICF) induced by heavy ions (HIs) at low projectile energy has been a topic of resurgent interest in nuclear physics. ICF may help to get the description of complete reaction dynamics, as it constitutes a significant part of total reaction cross section. In contrast to complete fusion (CF) process, at higher beam energy complete amalgamation of the projectile or all its fragments with target nucleus takes place, in the ICF process the complete transfer of mass, linear or angular momentum does not occur [1, 2]. The first observation of ICF was reported in ref. [1]. A remarkable work on ICF dynamics was carried out using the charged particle-γ coincidence measurements [2]. Several theoretical models namely; the break up fusion model, promptly emitted particles (PEP) model, hot spot model and Sumurule model etc. have been proposed to explain the incomplete fusion. These models are unable to explain the gross features of ICF at energies below 10 MeV/nucleon.

Several types of measurements are performed employing different techniques i.e., excitation function (EFs), forward recoil range distribution (FRRDs), transition intensity distributions etc. [3-5]. However, limited information on the angular distributions (ADs) of ERs populated via CF and ICF channels is available in literature. In this respect, an effort has been made to probe the ICF dynamics through the measurements of ADs of ERs produced in the system ^{16}O + ^{146}Nd at beam energy ≈6 MeV/nucleon.

Experimental details

The experiment was performed using 15 UD Pelletron accelerator at Inter University Accelerator Centre (IUAC), New Delhi, India. The enriched ^{146}Nd target of thickness ≈0.59 mg/cm^2 backed by thick aluminum (Al) foil was used for ADs measurements. A stack of thick annular concentric Al catcher rings of thickness ≈0.5 mm was used to capture the ERs. The angular stack was consisting of thick concentric annular Al catchers of diameters 0.5 cm, 0.8 cm, 1.3 cm, 1.8 cm, 2.3 cm, 3.0 cm, and 4.0 cm, respectively. These Al rings correspond to seven forward angular zones, viz. 0°–10°, 10°–17°, 17°–27°, 27°–37°, 37°–45°, 45°–54°, and 54°–62°. This arrangement of angular rings was placed 1.35 cm behind the target for collecting the ERs populated in the irradiation of target. The target was irradiated for ≈15 hours. After the irradiation, the in vacuum transfer facility (IVTF) was used to take out the stacks of ^{27}Al catchers along with ^{146}Nd targets from the scattering chamber. The target-catcher assembly was taken apart to record the activities induced in the individual irradiated catcher rings. The activities induced in each ^{27}Al catcher ring was recorded individually at increasing intervals of time using pre-calibrated high-resolution high-purity germanium (HPGe) detectors coupled to a CAMAC based personal computer employing CANDLE software [6].

Results and discussion

The ERs populated via complete and incomplete fusion channels were found to be distinctly different for the measured ADs. The present results of ADs reveal that the residue formed by CF tends to recoil in the forward cone and at smaller angles whereas residues populating via

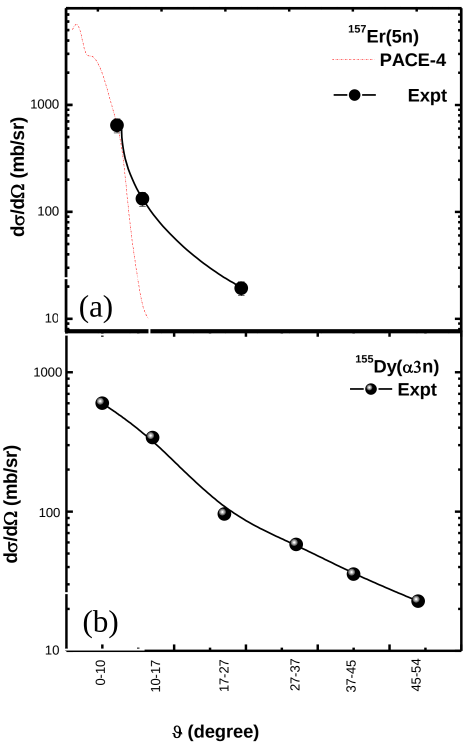

Fig. 1. Measured angular distributions along with theoretical predictions of PACE4 code for ERs (a) ^{157}Er (5*n*) and (b) ^{155}Dy (α3*n*) populated in the ^{16}O + ^{146}Nd system at projectile energy ≈6 MeV/nucleon.

ICF distribute in larger angular ranges. It comes out here that the ERs populated via *xn/pxn* channels in the system ^{16}O + ^{146}Nd are emitted in the forward angular zone up to ≈28°. As a representative case, the measured ADs of ER ^{157}Er (5n) along with its PACE-4 predictions is shown in Fig. 1(a). It can be observed from this figure that there is a reasonable agreement between measured and theoretical ADs for angular zone 0^0-17^0. However, the measured values of ADs were also found at larger angles ≈17^0- 27^0 as compared to PACE-4. These observations indicate that this ER is expected to be populated through CF of ^{16}O with ^{146}Nd target. On the other hand, the measured ADs of ER ^{155}Dy (α3n) along with its PACE-4 predictions is also shown in Fig. 1(b). This figure shows that the ER populated via α- emission channels were found to be trapped at larger angular zone up to ≈54° as compared to CF channels. This comparison clearly shows that the ERs of ICF channels are populated in the larger angular zone as compared to ERs of CF channels.

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