Probing of complete and incomplete fusion dynamics by the measurement of excitation function in ^{16}O + ^{124}Sn system

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Introduction

The study of complete and incomplete fusion dynamics in heavy ion collisions with medium mass target nuclei above the Coulomb barrier has been a subject of interest from past few decades. It has been observed that complete fusion (CF) and incomplete fusion (ICF) of the projectile with the target, at projectile energies above the Coulomb barrier may be considered as most dominant reaction modes [1-2]. In CF process, the incident projectile completely fuses with the target nucleus forming a highly excited compound system. This compound system decays by particle emission and characteristic γ-rays emitted from the evaporation residues. In this process complete linear momentum of the projectile transfer to the compound system. On the other hand, in case of ICF process, the break-up of projectile takes place into two fragments, one of which fuses with the target and the other moves as spectator in forward direction with almost same velocity as that of the incident ion beam with incomplete linear momentum of the projectile transfer to the composite system.

Britt and Quinton [3] were observed the ICF process experimentally the first time, who observed the breakup of incident projectiles like ^{12}C, ^{14}N and ^{16}O into alpha clusters in an interaction with the surface of the target nucleus at ≈ 10.5 MeV/nucleon bombarding energies. However, the study by Inamura *et. al*. [4] gave more strength to the ICF process.

In present work, an attempt has been made to measure the excitation functions of evaporation residues produced in ^{16}O + ^{124}Sn system at energies ranging ≈50-100MeV.

Experimental Details

The present experiment has been performed at Inter University Accelerator Centre (IUAC), New Delhi. Enriched targets of ^{124}Sn with purity better than (99.9%) were prepared by were prepared by vacuum evaporation technique at Target Laboratory of IUAC, New Delhi, India. The thickness of each target foils was determined using micro-balance as well as by α-particle transmission method. Two stacks of target-catcher assemblies were bombarded with the ^{16}O-ion beam in a General Purpose Scattering Chamber (GPSC). The targets in the stack along with catcher foils were arranged in such a way that target material faced the beam, so that the recoiled residues may be trapped in the Aluminium catchers. Each stack consisting of four foils of ^{124}Sn backed by thick aluminum catchers were irradiated with ^{16}O ion beam. The activities induced in the irradiated targets ^{124}Sn along with aluminum catchers has been recorded using a 100 c.c. high purity germanium (HPGe) detector coupled with a PC based data acquisition system employing with software CANDLE. The calibration of the HPGe detector was done using ^{152}Eu-source of known strength. The ERs were identified by their characteristic γ-rays as well as following their half-lives.

Results and Discussions

The EFs of the following three reactions: ^{124}Sn (^{16}O, 5n)^{135}Ce, ^{124}Sn(^{16}O, α5n)^{131}Ba and ^{124}Sn(^{16}O, 2α5n)^{127}Xe have been measured for the ^{16}O + ^{124}Sn system between projectile energy range ≈50-100MeV. The experimentally measured excitation functions have been compared with PACE-4 predictions and as shown in Fig. 1 (a)-(c).

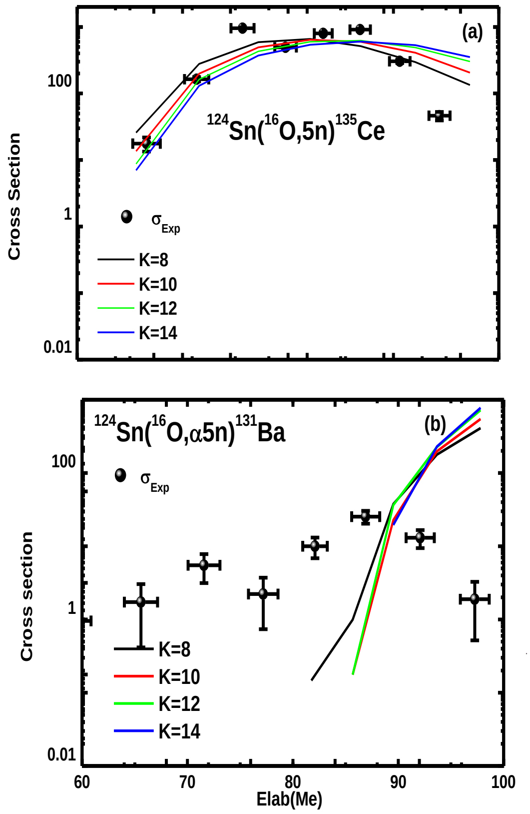

Fig.1 Experimentally measured and theoretically calculated excitation function for the reaction (a) ^{124}Sn(^{16}O, 5n)^{135}Ce and (b) ^{124}Sn (^{16}O, α5n)^{131} Ba.

The effect of variation of level density parameter (K=8,10,12,14)on the calculated EFs for the ERs produced in the reaction ^{135}Ce (5n) and ^{131}Ba (α5n) are shown in Figs.1(a)-(b). It is clear from the Fig.1 (a) that PACE-4 predictions corresponding to K=8 agree well with measured EFs. This reaction channel may be produced through CF process. The measured values of cross sections in the lower projectile energy region in Fig. 1(b) are enhanced from PACE-4 predictions (K=8) suggesting the contribution of CF and ICF, while at higher bombarding energies both the trend and magnitude of measured cross sections are different as predicted by PACE-4. At higher bombarding energies the theoretical prediction are much higher than experimentally measured cross-sections, it indicate that the residue ^{131}Ba(α5n) not only populated by CF and ICF but also produced through processes other than CF and ICF.

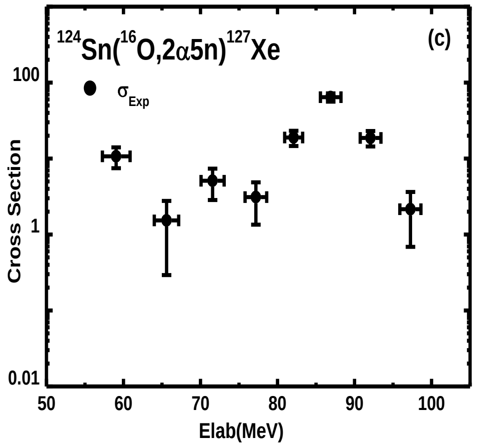

Fig.1 (c) Experimentally measured excitation function for the reaction ^{124}Sn (^{16}O, 2α5n)^{127} Xe.

The PACE-4 predictions for the evaporation residue ^{127}Xe (2α5n) gives negligible cross-section values and hence they are not shown in the Fig. 1(c). Thus, the observed enhancement over their negligible theoretical predictions for this channel may be attributed to the fact that the residue ^{127}Xe (2α5n) most likely to be populated by the ICF process .

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