Study of reaction dynamics in $^{16}O+^{115}In$ system using Recoil Range Distribution

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Introduction

The study of reaction dynamics of heavy ion (HI) induced reactions has been a topic of interest at incident energies from Coulomb barrier to 7 MeV/ nucleon [1]. The Incomplete Fusion (ICF) reactions had been observed for the first time by H.C. Britt and A.R. Quinton [2] at 10.5 MeV/nucleon energy. But recent studies show that the ICF competes with Complete Fusion (CF) even at energies just above the Coulomb barrier. It has been observed that ICF reaction dynamics depends on various entrance channel effects such as projectile energy, mass asymmetry of interacting ions and input angular momentum [3].

To study the comparison between CF and ICF, Forward Recoil Range Distribution (FRRD) is used as a probe [4]. Moreover, CF and ICF products can be disentangled on the basis of recoil velocity of reaction products, depending upon the degree of linear momentum transfer [5]. Hence, the present work is carried out to study the interplay between CF and ICF reaction dynamics, using recoil range distribution in $^{16}O+^{115}In$ system at about 102 MeV energy.

Experimental Details

The experiment was carried out at the Inter University Accelerator Centre (IUAC), New Delhi. The FRRD of evaporated residues were measured using ≈1 mg/cm^2 thick indium target (containing 95.7% ^{115}In and 4.3% ^{113}In). The contribution of ^{113}In isotope was negligible [6], which was considerable only at lower energies (≈55MeV), hence we have neglected the consideration of ^{113}In data. The indium target was deposited on Al-backing (≈1.03 mg/cm^2) by Vacuum Evaporation Technique. For stopping the evaporation residue produced via CF and/or ICF, Al-catcher foils of various thicknesses were used. The thickness measurement of target and catcher foils was done by α-transmission method. The target and catcher assembly was irradiated for about 12 hours with $^{16}O^{7+}$ ion beam in General Purpose Scattering Chamber (GPSC) using In-Vacuum-Transfer Facility. A pre-calibrated (100 cc.) HPGe detector coupled to a CAMAC based FREEDOM software was used for recording the γ-rays activities induced in different catcher foils.

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Results and Discussion

In order to obtain the yield distribution as a function of cumulative depth in the catcher stack, the cross section for each catcher was divided by its measured thickness. This yield has been plotted against the cumulative catcher thickness. The forward recoil range in the stopping medium of the residue produced through ICF is expected to be relatively lower than that produced through CF wherein entire linear momentum transfer takes place.

Experimental recoil ranges of residues are fitted by Gaussian peaks using the ORIGIN software. The most probable mean range (R_p) and width parameter (w_A) (which is equivalent to full width at half maximum) has been obtained from the observed recoil range distributions of various residues and area under the peaks. Individual peak has been computed to obtain the CF and ICF contribution. The relative contributions of the CF and ICF processes were obtained by dividing the area of the corresponding peak by the total area. Forward recoil ranges of evaporation residues have also been calculated using the classical approach, the stopping power and range software SRIM-08 [7].

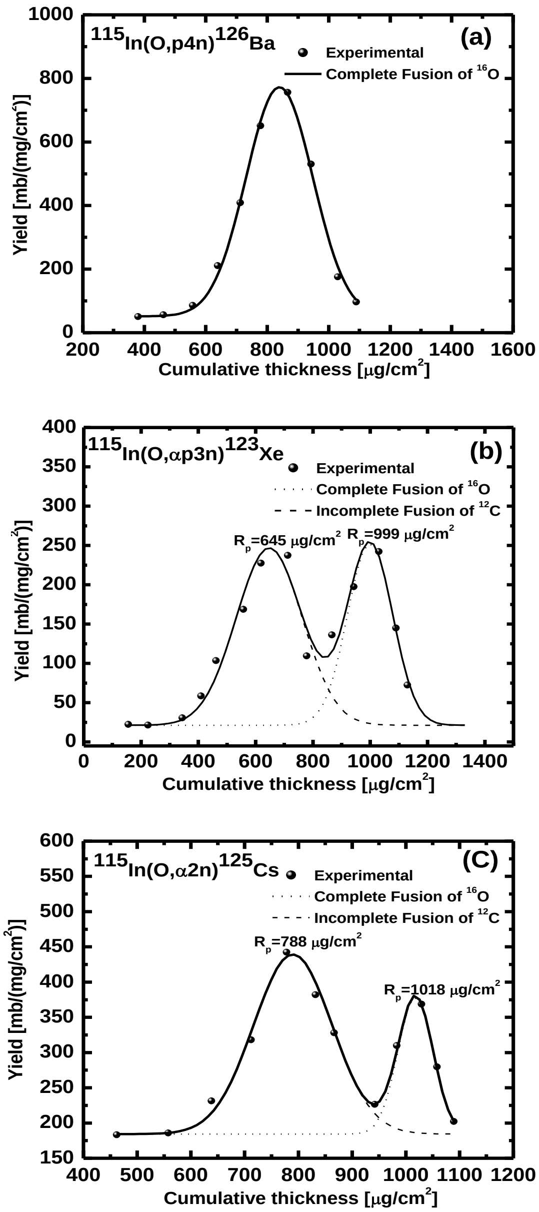

Fig.1. Recoil Range Distribution of ^{126}Ba, ^{123}Xe and ^{125}Cs residues.

In order to separate out the relative contributions of CF and ICF evaporation residues produced via complete fusion and α-emission channels have been measured for ^{16}O + ^{115}In system. The energy ≈105 MeV was incident on Al-backing so that reduced energy which strikes the indium target was ≈102 MeV. As a representative case the RRD of the three residues, ^{126}Ba, ^{123}Xe and ^{125}Cs are plotted in Figs.1(a-c). Fig.1(a) for residue ^{126}Ba shows one peak corresponding to the recoil range ≈840 μg/cm^2, which is formed after the decay of completely fused composite system ^{131}La* (formed due to CF of ^{16}O, which further decays into ^{126}Ba via emission of 1 proton and 4 neutrons). Fig.1(b) related to ^{123}Xe residue shows two peaks in its distribution pattern corresponding to the recoil range (R_p) ≈999 μg/cm^2 and 645 μg/cm^2, which agree well with the theoretical mean range calculated for completely fused composite system ^{131}La* (formed due to CF of ^{16}O, which further decays into ^{123}Xe via emission of 1 α-particle, 1 proton and 3 neutrons) and incompletely fused composite system ^{127}Cs* (formed due to fusion of ^{12}C and may decay into ^{123}Xe via emission of 1 proton and 3 neutrons). In Fig.1(c) the RRD pattern of evaporation residue ^{125}Cs also shows two peaks, revealing the presence of more than one linear momentum transfer component with cumulative catcher thickness of ≈1018 μg/cm^2 (due to CF of ^{16}O) and ≈788 μg/cm^2 (due to ICF of ^{12}C) respectively. From the figures 1(b) and 1(c) it may be interpreted that both residues are populated via CF as well as ICF processes. The relative contribution for the residue ^{123}Xe coming from the CF and ICF is found to be ≈41% and ≈59% respectively, while in case of ^{125}Cs it is found 26% and 74%.

From the present study it is found that the angular momentum of projectile plays an important role in deciding CF and ICF processes even at moderate energies.

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