Study of reactions involving incomplete mass transfer in ^{28}Si+^{93}Nb reaction

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Introduction

Study of reactions involving incomplete mass transfer has been an active area of investigation in low and medium energy nuclear reactions. These reactions can be categorized into quasi-elastic transfer (QET), incomplete fusion (ICF) and deep inelastic collisions. Kinetic energy spectra and angular distributions of projectile like fragments and evaporation residue yields give information about the contribution from different types of mechanisms [1]. QET involves transfer of a few nucleons from lighter to heavier reaction partner. ICF reactions involve large mass transfer from lighter to heavier reaction partner. DIC involves mutual exchange of nucleons between the projectile and the target nuclei, leading to wings around projectile and target masses in the mass distribution. Products close to the projectile and target masses may also arise due to the direct pick-up and stripping reactions. In addition to these reactions, there can be contribution from fission like events. Contribution from these various processes depends on the projectile energy and entrance channel mass asymmetry. In reactions involving light projectiles such as ^{12}C, ^{16}O, ^{19}F and ^{20}Ne on various targets, incomplete fusion and quasi-elastic transfer are observed as the dominant non-compound processes in the beam energy range below ~6 MeV/Nucleon [1-5]. Mathews et al. [6] reported growth of the projectile at the expense of target in ^{20}Ne+^{nat}Cu, ^{197}Au reactions at higher beam energies. In addition to beam energy, entrance channel mass asymmetry also plays an important role in governing the contribution from different reactions involving incomplete mass transfer. Measurement of cross section of evaporation residues in ^{16}O+^{66}Zn and ^{37}Cl+^{45}Sc showed much larger cross section for incomplete fusion in ^{16}O+^{66}Zn reaction compared to that in ^{37}Cl+^{45}Sc reactions [7]. Beam energy for ^{37}Cl+^{45}Sc reaction in this study was below ~3.5 MeV/nucleon. It would be important to investigate the contribution from various reactions involving incomplete mass transfer in such less asymmetric systems at higher beam energies. In addition to the contribution of incomplete fusion reactions, such reaction systems also become interesting due to the possible contribution from fission, arising mainly due to the population of large *l*-waves, leading to the substantial lowering of the fission barrier, which becomes more pronounced for the symmetric split [8].

In the present work, evaporation residues have been measured in ^{28}Si+^{93}Nb reaction at E_{lab}=103 and 155 MeV by recoil catcher technique followed by off-line γ-ray spectrometry to investigate the contribution from various types of reactions involving incomplete mass transfer.

Experimental details

Experiments were carried out at BARC-TIFR Pelletron–LINAC facility, Mumbai. Self supporting targets of ^{93}Nb were irradiated with ^{28}Si beam at beam energies of 110 and 160 MeV. Average energies at the centre of the target were 103 and 155 MeV respectively due to the beam energy degradation in the target. Irradiations were carried out for about 9 and 7 hrs at lower and higher beam energies respectively. Two aluminium catcher foils were kept in the forward direction to stop the recoiling reaction products. The thickness of first catcher (catcher 1) foil was about 750 μg/cm^2 and that of the second catcher foil was about 6.75 mg/cm^2. This target catcher arrangement helped in distinguishing the reaction products formed in collisions involving different amount of linear momentum transfer. After irradiation, target and catcher foils were separately counted for the γ-rays of the reaction products using a HPGe detector coupled to a multichannel analyser. The decay of reaction products was followed for more than three months.

Results and discussion

From the γ-ray spectra, several reaction products with atomic number in the range of 39 to 52 were observed. No signature of the fission like products was observed. Typical γ-ray spectra of targets and the first catcher foils are shown in Figs. 1 and 2 respectively. Gamma-ray spectra of lower and higher beam energies are shown as dotted and solid lines respectively. All the spectra correspond to a cooling of about three days and have been counted for 5000 s. Gamma-lines of the some of the reaction products are marked in these figures. It can be seen from these figures (catcher 1, lower spectrum) that $^{111}In^{g}$, predominantly formed in massive transfer reaction, is seen mainly at the higher beam energy. Whereas products having Z close to that of the target such as Tc isotopes are dominant at both the beam energies. This observation is consistent with the faster decrease in the cross sections for the large mass transfer channels. Products having Z lower than that of the target

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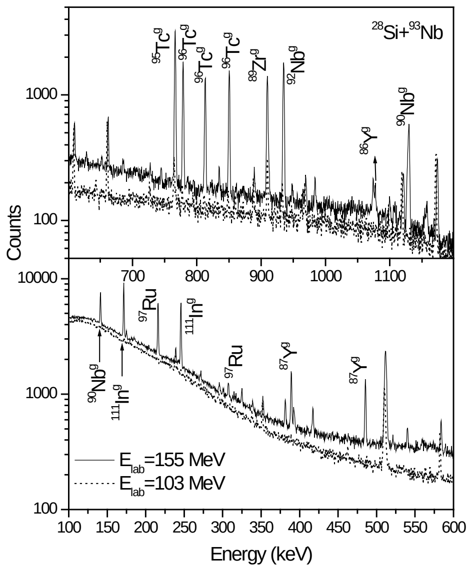

Fig. 1. Gamma-ray spectra from targets.

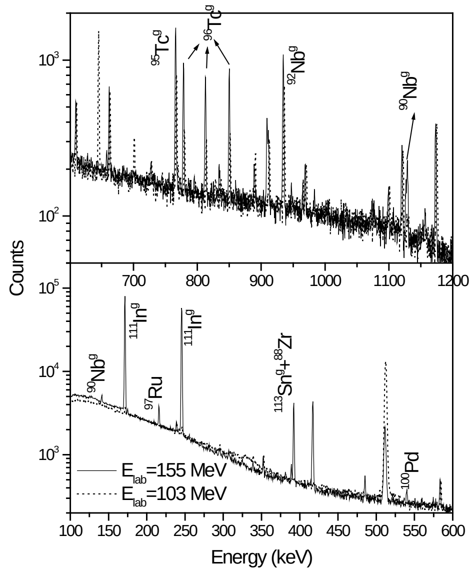

Fig. 2 Gamma-ray spectra from the first catcher foils.

indicate the contribution from stripping and/or DIC type of reactions. Further analysis is in progress to obtain the cross sections of these reaction products for a quantitative comparison with the theoretical calculations.

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