Exploring the dynamics of pre-compound emission reactions at low-energy

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Recently, at low energy below 10 MeV/nucleon, the pre-compound emission (PCN) process in light ion-induced reactions has been extensively investigated over a wide range of mass regions [1-4], where a mass number dependence systematics, the role of target deformation and shell closure on PCN process have been greatly explored. However, such studies are quite limited in heavy ions (HIs) reactions due to the dominance of the breakup fusion (BUF) process at these energies. Despite the influence of the BUF process, the presence of PCN emission in HI reactions at low projectile energy 4-7 MeV/nucleons is of considerable interest indicating a crucial role of angular momentum in these reactions [5].

The present work is part of an ongoing program investigating the dynamics of HI interactions at low energy. At such energy, the PCN emission is found to compete with the compound nucleus (CN) process for xn reaction channels, while for alpha-emitting channels, a strong competition between CN and BUF is observed. If the contribution of each process CN, PCN, and BUF is independently determined, it will be an interesting development. Such investigations may give a mass number dependence systematics on the PCN process and unveil the role of angular momenta-involved in the reactions.

In order to obtain the contribution of PCN emission in the reactions, experiments have been carried out for measurements of the excitation functions (EFs), recoil range distributions (RRDs), and spin distributions (SDs) at the Inter-University Accelerator Centre (IUAC), New Delhi by using different beams ^{12}C, ^{14}N ^{16}O and ^{19}F on several target nuclei ^{159}Tb, ^{165}Ho, ^{169}Tm, ^{175}Lu, and ^{181}Ta. The measurements of EFs give a qualitative description of the CN, PCN, and BUF processes [6], however, quantitative information may be obtained by measuring RRDs and SDs of the reaction products [7].

In the RRD experiments, the target following a stack of nearly 15 thin Al catcher foils of varying thickness (≈16-45 μg/cm^2 prepared by the vacuum evaporation technique) was mounted in the irradiation chamber normal to the beam direction. Depending on the momentum carried away by the product residues, the recoiling residues were trapped at different ranges in the stack of thin Al foils. The thickness of the catcher foils was measured precisely before their use, by measuring the energy loss

suffered in each catcher foil by 5.485 MeV α- particles from ^{241}Am source.

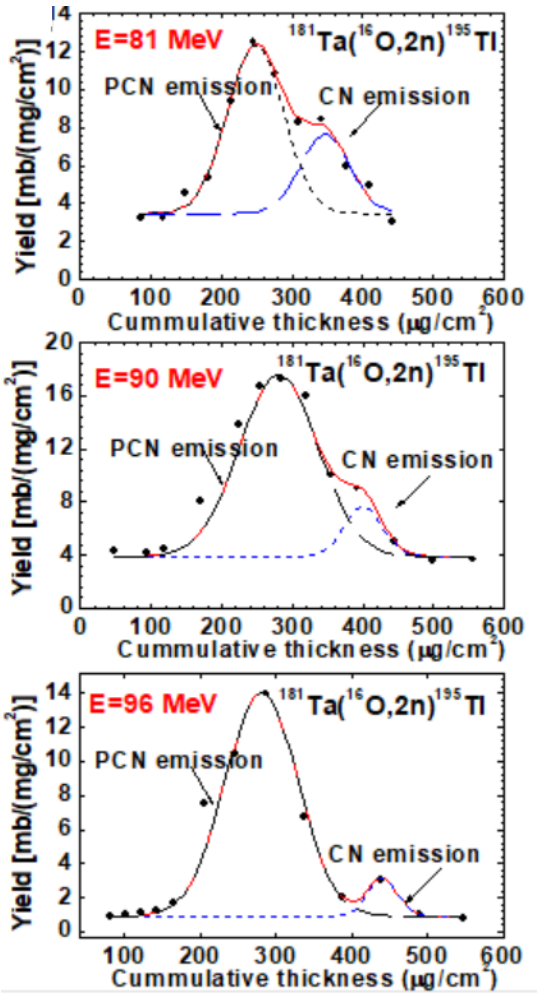

Fig. 1 The measured RRDs for reaction ^{181}Ta(^{16}O,2n)^{195}Tl at energies 81, 90 and 96 MeV

The activities induced in each thin catcher were followed off-line for about two weeks using a pre-calibrated high-resolution HPGe detector. The RRD is based on momentum carried away by the reaction products and is used to decipher the components of CN, PCN, and BUF processes at low energies around 5-6 MeV per nucleon[7,8]. As a typical example, the measured RRDs for the reaction ^{181}Ta(^{16}O,2n)^{195}Tl at three different energies 81, 90 and 96 MeV are shown in Fig 1. In this figure, two distinct peaks are assigned for different linear momentum components involved corresponding to PCN and CN processes. The analysis of SDs of the residues gives the mean input angular momentum associated with CN, PCN, and BUF processes. Further experimental details about the RRDs and SDs will be presented.

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