Incomplete fusion reactions in $^{16}O + ^{51}V$ system

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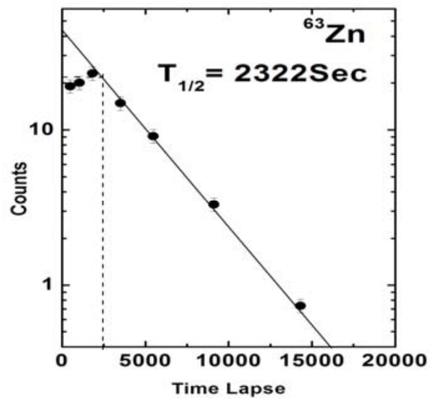
Introduction

Recently, there is a resurgent interest in the study of the incomplete fusion (ICF) dynamics after the observation of its strong influence on complete fusion (CF) at energies ≈ 4-7 AMeV [1-2]. The study of HI interaction is thoroughly specific because of its complex structure and large momentum involved. In CF process, the projectile nucleus completely fuses with the target nuclei forming a highly excited compound system. This compound system decays by particle emission along with their characteristic γ-rays. On the other hand, for 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 target. Both the processes are also characterized by the angular momentum carried by the projectile. Our earlier study [3] and Morgenstern et al. [4] established the dependence of the ICF reaction on entrance channel mass-asymmetry and projectile energy. The ALICE-91code is found to reproduce the experimental observations more satisfactory than those obtained from PACE-4 for low mass system.

Experimental Details

The experiment has been carried out at 15UD Inter-University Accelerator Centre (IUAC), New Delhi (India), using the General Purpose Scattering Chamber (GPSC) facility. The self supporting targets of V^{51} each of thickness 1.987 mg/cm^2 and the Aluminum catcher foils of thickness 1.8378 mg/cm^2 have been prepared by vacuum evaporation technique and rolling technique respectively. A stack containing five samples of target-catcher assemblies has been irradiated in the GPSC facility of IUAC using $^{16}O^{7+}$ projectile beam at energy ≈ 100MeV. The thickness of target and catcher assembly was chosen in such a way that it covers the energy range about 4 MeV/A – 8 MeV/A. The thickness of the targets and the catcher foils have been confirmed by α-transmission method. Keeping in mind the half-lives of radioisotopes of our interest, the stack was irradiated for ~ 6.35 hrs with beam current ≈33 nA. The evaporation residues have been identified by their characteristic decay γ-rays and confirmed by their half life measurements which are found to be in good agreement with the literature values (see figure – 1)[5].

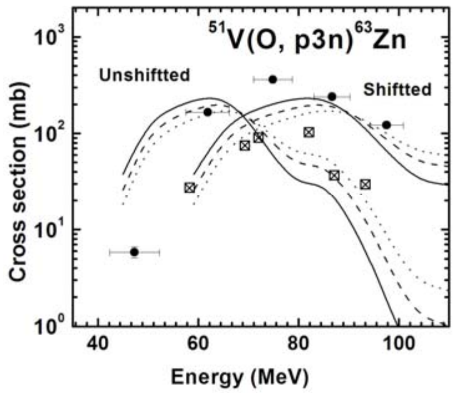


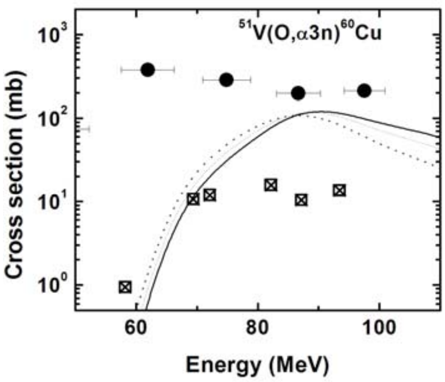
Results and Discussion

The excitation functions for eleven ERs populated through (O, 2n), (O, p3n), (O, p4n), (O, α2n), (O, α3n), (O, α2p), (O, 2αn), (O, 2α2n), (O, 2α3n), (O, 3αn), (O, 3α3n) channels have been measured in the energy range of 4-8 MeV/A. The measured values have been compared with earlier measurements [6] and theoretical values obtained from the code ALICE-91 [7] used to calculate the equilibrium (CN) and pre-equilibrium emission cross-section in both light and heavy ion induced reaction. The various parameters used in calculation of excitations were selected as in our earlier publications [8, 9]. It is observed that highest value of measured excitation functions were shifted towards the higher energies side than the theoretically calculated value. This may be due to the fact that in ALICE-91 calculations the angular momentum effects have not been considered. In heavy ion induced reaction the incident projectile impart large angular momentum to the composite system. The compound system attained with incident particles of different masses, have different angular momenta in sufficient amount, when excited to the same excitation energy. In the last stage of nuclear de-excitation the high angular momentum transmitted by heavy ions prevent particle emission more than it does gamma ray emission, then the peak of the excitation function correlated with the particle emission mode will be shifted towards the higher energy side [9,10]. This shift can be obtained from the rotational energy. For rigid body the rotational energy is expressed by $E_{rot} = (m/M)E_{lab}$, where *m, M* and E_{lab} are projectile mass, target mass and projectile energy [9,10]. As a representative case the excitation functions for (p3n) and (α3n) channels have been presented. It can be seen from figures that for α3n channel the measured excitation functions are much higher than the theoretical predictions. Which clearly indicates the presence of ICF with CF. Further the incomplete fusion fraction is also found to depend on the projectile energy. The variation of ICF fraction with mass asymmetry has also been investigated.

Conclusion

The excitation functions of different residues have been measured for $^{16}O + ^{51}V$ system. The large enhancements in the cross-section have been observed over the ALICE-91 predictions for α-emitting channels. This enhancement has been accredited due to incomplete fusion of projectile with target. It has also been observed that the ICF depend on incident projectile energy.





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