Effect of two neutron excess projectile on low energy incomplete fusion dynamics

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Wide spread efforts have been employed in recent years to understand the competition between complete and incomplete fusion reaction dynamics at energies near and above the Coulomb barrier [1]. In case of CF process, for $\ell \leq \ell_{critical,}$ the entire projectile is trapped by the target nucleus. However, at $\ell \geq \ell_{critical}$, the centrifugal potential becomes larger than the sum of repulsive Coulomb and attractive nuclear potential due to which the fusion of two interacting partners is strongly hindered. Therefore, to release the extra input angular momenta, the projectile is assumed to breakup into fragments near the vicinity of the target nucleus. One of the resulting breakup fragments may get fused with the target nucleus and results the formation of a hot metastable incompletely fused composite system having relatively lower mass, charge and excitation energy. The cross-section for such reactions has been required to understand the synthesis of super-heavy nuclei and also provides an opportunity to explore the nucleus-nucleus potential. Britt & Quinton [2], first observed the emission of very energetic projectile like fragments (PLFs) in the bombardment of ^{197}Au and ^{209}Bi by ^{12}C, ^{14}N and ^{16}O projectiles at energies ≥ 10.5MeV/nucleon. Various theoretical models have been proposed and tested to explain the mechanism of ICF reactions but are unable to reproduce the experimental ICF data satisfactorily below 10 MeV/nucleon which makes the study of ICF, still an active area of investigations. To understand the proper mechanism of ICF reactions, the dependence of ICF on various entrance channel parameters like projectile energy, binding energy and/or α-Q-value, target charge (Z_PZ_T), driving input angular momenta, mass asymmetry, deformation of interacting partners etc., need to be explored. Sufficient data is available in the literature for reactions involving α-cluster projectiles but data with non α-cluster beams are comparatively scarce. Therefore, the effect of non α-cluster over α-cluster projectiles will be studied. In the present work, an attempt has also been made to understand the above aspects in a reliable way from excitation function (EFs) measurement of evaporation residues for the system ^{18}O+^{165}Ho at energies 4-7 MeV/nucleon.

The experiment of the present work has been performed at the Inter University Accelerator Center (IUAC), New Delhi, India using the $^{18}O^{7+}$ beam. Self-supporting ^{165}Ho targets of thickness ≈ 1.0–1.5 mg/cm^2 and Al-catcher foils of thickness ≈ 1.5–1.7 mg/cm^2 were prepared by the rolling technique. These Al- foils serve both as catchers as well as energy degraders to cover the desired energy range. The thickness of each target and catcher foils has been separately measured through weighing and by α-transmission method. Two stacks each having four ^{165}Ho target foils backed by Al-foils were irradiated for about 9-10 hours in General Purpose Scattering Chamber (GPSC), keeping in mind the half-lives of interest. During the irradiations, the total charge collected in the Faraday cup, placed behind the target catcher foils, have been used to calculate the beam flux. The activities induced in each target catcher foils were recorded by using a pre-calibrated (100cc) High Purity Germanium (HPGe) Detector coupled to a CAMAC-based CANDLE software. The geometry-dependent efficiencies of the HPGe detector at various source detector positions were obtained by using the standard ^{152}Eu source.

The EFs of several evaporation residues $^{179\text{-}177}$Re (xn; x = 4-6), ^{177}W (p5n), and $^{178,\ 176,175}$Ta (αxn; x =1, 3-4) etc. produced in ^{18}O+^{165}Ho interactions have been measured and analyzed within the framework of statistical model code PACE-4 [3]. Based on the Hauser-Feshbach theory, the code PACE-4 predicts only CF channels and does not take transfer and/or breakup ICF channels into account. Hence, any deviation in the experimental EFs from the PACE-4 calculations may be attributed to the onset of ICF. To reproduce the experimental EFs, the level density parameter (a= A/K) plays an important role in this code. In the present work, different values of K = 8 –10 have been tested to reproduce fusion EFs and have been plotted in Figs. 1 & 2. From Fig.1, it is clear that the experimentally measured cross–sections well matched with theoretical predictions for free parameter value K = 8, which indicates that residue^{178}Re (5n channel) is populated via CF process only. Similarly other identified xn and pxn channels are suitably reproduced by the same set of parameters, indicating their population via CF process only. Alternatively, the EF of residue as shown in Fig.2 shows significant enhancement in measured cross sections over theoretical predictions. This enhancement is attributed to ICF process and indicates that ICF process also contributes in the population of ^{175}Ta (α4n) along with CF process.

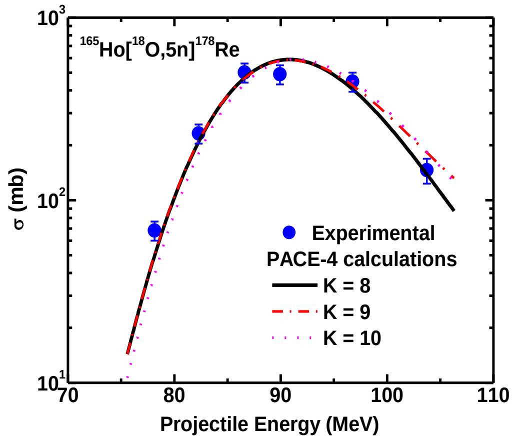

Fig.1. Excitation Function of residue ^{178}Re (5n) produced in ^{18}O +^{165}Ho system.

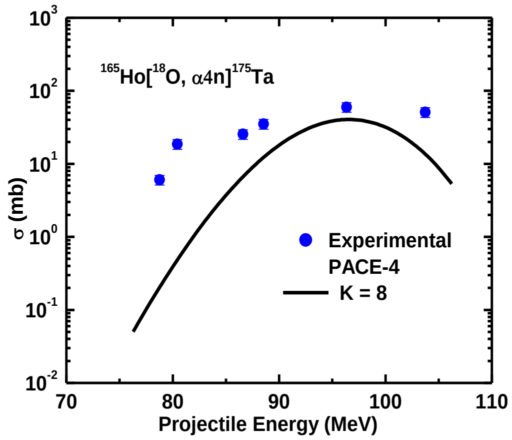

Fig.2. Excitation Function of residue ^{175}Ta (α4n) produced in ^{18}O +^{165}Ho system.

In order to reach on some definite conclusion about alpha-Q value systematics, the present data will be compared with ^{16}O +^{165}Ho [4] and ^{20}Ne +^{165}Ho [5] data, as ^{18}O has more negative Q_{α}-value than ^{16}O and ^{20}Ne. For better understanding of ICF process, the ICF fraction has been deduced and found to be energy dependent. Further, information regarding the effect of projectile structure and α-Q value on the ICF strength functions and comparison with ^{16}O +^{165}Ho and ^{20}Ne +^{165}Ho data will be presented. Also the effect of neutron access projectiles over α-cluster projectiles will also be presented.

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