Fusion incompleteness in non α cluster projectile: Role of excess neutrons

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Introduction

In the recent past, extensive efforts were made to explore the dynamics of heavy-ion (HI) (Z $\geq$ 2) induced reactions and the role of projectile structure in influencing the degree of fusion incompleteness [1]. Fusion reaction induced by α cluster projectiles have the minimal probability for nucleon transfer and prefer to undergo breakup fusion or fusion reactions [2]. Contrary to α cluster projectiles, it was observed that fusion reaction induced by non α cluster projectiles proceeds via transfer of excess nucleons to target nucleus [3]. After the first observation of incomplete fusion (ICF) reaction by Britt and Quinton in year 1961 [4], extensive efforts were made to explore its reaction dynamics.

In case of HI induced reactions at $E_{lab} \approx$ 4-7 MeV/A, it was observed that evaporation residues (ERs) were populated mainly through complete fusion (CF) and incomplete fusion (ICF) processes. In the present work measurement of excitation function (EF) of observed ERs populated through different fusion processes in the ^{18}O + ^{165}Ho reaction at $E_{lab} \approx$ 78-104 MeV were carried out to study the role of non α cluster projectile in ICF reactions.

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Experimental Details

Experiment was carried out at Inter University Accelerator Centre (IUAC), New Delhi using ^{18}O ion beam by employing the activation foil technique. Target foils were placed in the form of stack comprising of ^{165}Ho targets interspersed with Al degrader foils. Rolling technique was used for the fabrication of ^{165}Ho target foils of thickness 1.0-1.5 mg/cm^2 and Al degrader foils of thickness 1.5-1.7 mg/cm^2. Irradiation of target-degrader foil assemblies, was done by ^{18}O ion beam at energies $\approx$ 87 MeV and 104 MeV in the General Purpose Scattering Chamber (GPSC). For proper identification of emitted γ-rays, detector was calibrated using standard ^{152}Eu source and coupled to a CAMAC based data acquisition system CANDLE.

Results

In the interaction of ^{18}O projectile with ^{165}Ho target at $E_{lab} \approx$ 78-104 MeV, a total of eleven ERs namely, $^{179-177}$Re ,^{179,177}W, $^{178,176-174}$Ta,^{173}Hf and ^{172}Lu were found to get populated through different fusion processes and the EF of these evaporation residues (ERs) were measured to explore the reaction mechanism involved in their population. Among the populated ERs, residues emerging through xn and pxn channels were likely to get evolved through CF process only. On the other hand, residues stemming out through α emitting channels have the dual probability of getting populated through CF

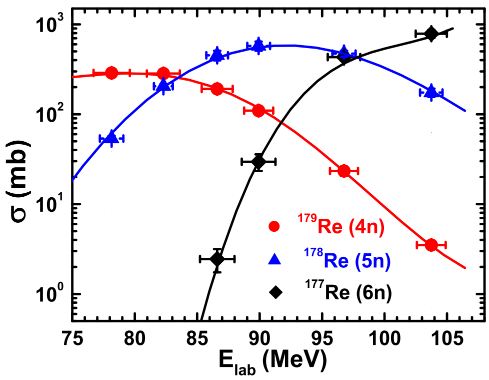

FIG. 1: Experimentally measured (solid bullets) and PACE4 calculated (solid lines) EF of ERs ^{179}Re, ^{178}Re and ^{177}Re populated through $4n$, $5n$ and $6n$ channels, respectively.

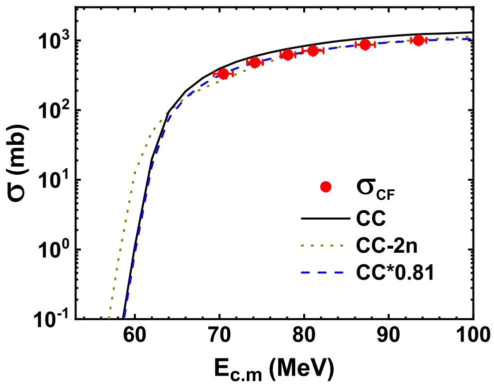

FIG. 2: Experimentally measured CF excitation function (solid circle) along with the CC calculations (solid line) performed using the code CCFULL for the ^{18}O + ^{165}Ho system.

as well as ICF processes. Fig. 1 shows the experimentally measured and PACE4 [5] calculated EF of ERs populated through xn ($x=$ 4,5,6) channels.

Coupled channel calculations were performed using the code CCFULL [6] with and without incorporating the additional $2n$ pair transfer channel with a Q value of +1.335 MeV and the nominal coupling strength of 0.7 MeV. Results of CCFULL calculations were shown in Fig. 2. As it can be infered from Fig. 2, there is small difference in CCFULL prediction with and without incorporating the $2n$ transfer channel at above the barrier energies. Experimentally measured fusion cross sections were found to lie sufficiently below the CCFULL predictions at above the barrier energies. In order to reproduce the experimentally measured fusion cross section data, CCFULL predictions were multiplied by a suppression factor of 0.81. Thus on the basis of CC calculations it can be concluded that above the barrier energies experimentally measured fusion cross sections for the ^{18}O + ^{165}Ho system were suppressed by 19% owing to breakup of the incident projectile (^{18}O) into 1α or 2α fragments prior to fusion with the target nucleus.

Conclusion

It was observed that ERs populated through xn and pxn channels show satisfactory overlap with the prediction of statistical model code PACE4 which ensures their evolution through compound reaction channel. On the other hand, ERs emerging through α emitting channels shows enhancement over the PACE4 prediction arising due to additional contribution from ICF processes in addition to CF. Results of CC calculations establishes that main α production mechanism must be due to breakup of the incident projectile which results in suppression of fusion cross section at above barrier energies.

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