Study of complete and incomplete fusion reactions at above the barrier energy using ^{19}F + ^{93}Nb system

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Introduction

During the last few decades several studies has been carried out to explore the influence of projectile breakup on fusion suppression at above the barrier energies [1, 2]. Breakup of the incident projectile, due to excessive Coulomb repulsion between the projectile and target, opens the doorway for a new class of reaction. Complete fusion (CF) and incomplete fusion (ICF) is most important among them. When the incident projectile, either as a single entity of in parts, fuses with the target nucleus it is called complete fusion. It was also observed that only a part of the incident projectile fuses with the target nucleus leading to incomplete fusion reaction. ICF reaction was first observed by Britt and Quinton [3] and later on enormous studies have been carried out to explore the dependency of ICF reaction dynamics on various entrance channel parameters. According to sum-rule model, proposed by Wilczynska *et al.* envisaged that CF process is localized in angular momentum space below certain critical value called critical angular momentum (ℓ_{crt}) [4]. Total fusion cross section is the algebraic sum of CF and ICF *i.e.* $\sigma_{TF} = \sigma_{CF} + \sigma_{ICF}$. Present work deals with the measurement of excitation function (EF) of evaporation residues (ERs) populated through ^{19}F + ^{93}Nb reaction at $E_{lab} \approx$ 65-100 MeV.

Experimental Details

Experiment was performed at Inter University Accelerator Centre (IUAC) New Delh using 15UD Pelletron accelerator facility. ^{93}Nb target foils were prepared at target lab of IUAC using rolling technique. Target foils of ^{93}Nb were irradiated with ^{19}F beam at $E_{lab} \approx$ 100 MeV. Target foils along with Al degrader foils were placed in the form of stack foil arrangement. Thickness of ^{93}Nb and Al degrader foils ranges from 1.70-2.02 mg/cm^2 and 1.30-1.70 mg/cm^2 respectively so that irradiation of target foils span over an energy range of $E_{lab} \approx$ 65-100 MeV. Thickness of target and degrader foils were measured by weighing as well as by α transmission method. Stack of ^{93}Nb target and Al degrader foils were irradiated with a beam current of $\approx$ 35 nA for $\approx$ 8 hrs. Soon after the stopping of beam current, activity of the populated ERs were recorded offline using the high purity Ge (HPGe) detector coupled to a CAMAC based data acquisition system.

Results

In the ^{19}F + ^{93}Nb reaction at $E_{lab} \approx$ 65-100 MeV, a total of twelve ERs were populated through various reaction channel. Among the populated ERs, residues populated through xn or pxn channel have the sole probability of get-

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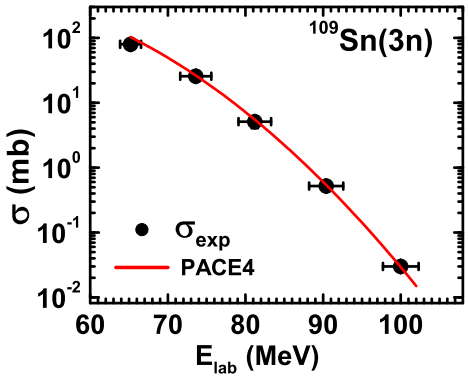

FIG. 1: Experimentally measured (solid bullets) and PACE4 calculated (solid lines) EF of residue ^{109}Sn populated through $3n$ channel.

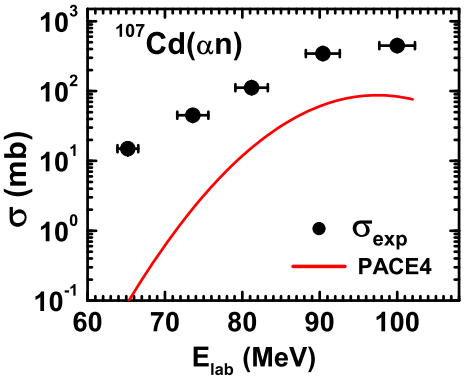

FIG. 2: Experimentally measured (solid bullets) and PACE4 calculated (solid lines) EF of residue ^{107}Cd populated through αn channel.

ting populated through the CF process. Complete fusion of incident projectile ^{19}F with the ^{93}Nb target leads to the formation of excited intermediate compound system ^{112}Sn* which further cools down through the emission of nucleon(s). EF of the ERs populated through different fusion processes were analysed in the frame work of statistical model code PACE4 [5]. Code PACE4 is based on Hauser-Feshback theory of compound nucleus decay and incorporate the contribution arising from CF process only. Experimentally measured EF of ERs populated through xn or pxn channel were well reproduced by the PACE4 calculations which can be inferred from Fig. 1 showing the EF of residue ^{109}Sn populated through $3n$ channel. Contrary to residues populated through xn or pxn channel, residues populated through α emitting channels have the dual probability of getting populated through CF as well ICF process. Fig. 2 shows the experimentally measured and PACE4 calculated EF of residue ^{107}Cd populated through αn channel. As it can be seen, experimentally measured EF shows an advancement over the PACE4 calculations.

Conclusion

In the present work experimentally measured EF of the ERs populated through CF and/or ICF processes in the ^{19}F + ^{93}Nb reaction at $E_{lab} \approx$ 65-100 MeV were analysed in the frame work of statistical model code PACE4. It was observed that experimental EF of residues populated through xn or pxn channels were well reproduced by the statistical model code PACE4 suggesting their evolution through CF process. On the other hand experimentally measured EF of ERs populated through α emitting channels shows an advancement over the PACE4 prediction which confirm the contribution of ICF process in addition to CF process in their origin.

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