Measurement of excitation functions in $^{16}O + ^{93}Nb$ at energies above the Coulomb barrier

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Introduction

From past few decades it has become the topic of great interest to study heavy ion (HI) induced reaction at intermediate energy range. It has been observed that at energies just above the Coulomb barrier both the complete fusion (CF) and incomplete fusion (ICF) reaction may dominant. In CF processes whole projectile fuses with the target while in ICF processes only a part of projectile fuses with the target and remaining part passes with almost beam energy. Some studies show that ICF competes with CF just above the Coulomb barrier [1-4]. Several theoretical models have been presented to explain the ICF reaction dynamics, such as Exciton model, Breakup fusion model, Promptly emitted particles model, Multistep direct reaction theory and Hot spot model etc.

In the present work an effort has been made to investigate the mechanism involve in HI reaction with measurement of excitation functions for thirteen evaporation residues (ERs) identified in the interaction of $^{16}O+^{93}Nb$ system.

Experimental details

The experiment was carried out at Inter University Accelerator Center (IUAC) New Delhi using $^{16}O^{7+}$ beam of energy 100 MeV on ^{93}Nb target in the General Purpose Scattering Chamber (GPSC). A stack made of five sample of ^{93}Nb foils sandwiched with four Aluminum catcher foils, of thickness 1.712 mg/cm^2 and 2.078 mg/cm^2 respectively, was used as the target. The stack was irradiated for ≈ 7 hrs, keeping in mind the half lives of interest. The activities produced in each target catcher assembly have been measured using a high resolution large volume (100c.c.) High-Purity Germanium detector (HPGe) γ-ray spectrometer coupled to a host computer through CAMAC based IUAC developed CANDLE, data acquisition system.

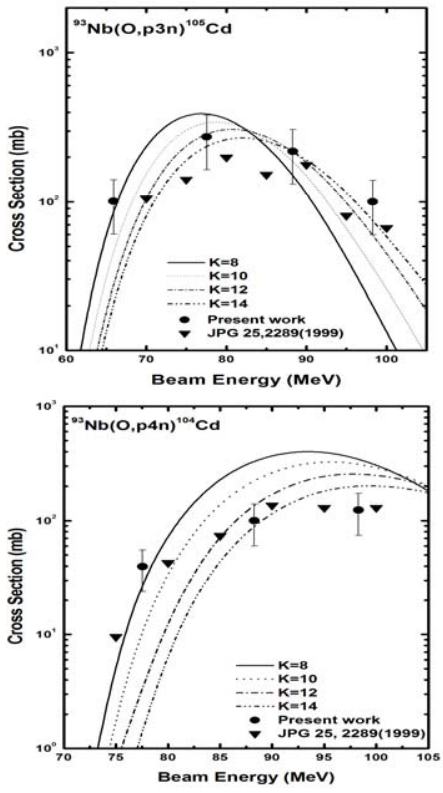

Fig.1 Experimentally measured and theoretically calculated EFs for residues populated via (p3n) and (p4n) channels in $^{16}O+^{93}Nb$ system

Results and Discussion

Excitation functions (EFs) for residues produced in the $^{16}O+^{93}Nb$ system via CF and/or ICF processes were measured at projectile energies up to ≈100 MeV. All possible identified γ-rays for each reaction channel are considered for cross-section measurement. The excitation functions for thirteen evaporation residues (ERs) populated though (O,p3n), (O,p4n), (O,α), (O,αn), (O,α2n), (O,αp3n), (O,αp4n), (O,2αn), (O,2α2n), (O,2αp3n), (O,3αn), (O,3α2n) and (O,3α3n) have been measured. The theoretical predictions of the EFs have been done with the statistical model code PACE-4. The PACE-4 code is based on Hauser-Feshbach approach. It may be pointed out that the ICF and PE-emission are not taken into consideration in this code while this formalism takes angular momentum directly into account.

Some of the experimentally measured excitations functions along with theoretical predictions have been shown in figure 1&2. A well agreement is found in experimental measured EFs and PACE-4 predictions for pxn channels (Fig.1). The enhancement of experimental cross-sections over PACE-4 predictions for α-emitting channels has been observed. This advancement in cross-section is signifies the ICF process over the coulomb barrier energies, Since PACE-4 code does not take ICF into account, therefore the contribution coming from incomplete fusion process as these residues may not only be populated via complete fusion but incomplete fusion is also contributing a significant role. This can be seen in case of ^{93}Nb (O,αn) ^{104}Ag and ^{93}Nb (O,α2n) ^{103}Ag reactions [as shown in figure.2]

Conclusion

The comparative study of experimentally measured excitation functions with theoretically calculated excitation functions shows considerable enhancement in the cross-section for α-emitting channels. Large difference in cross-section gives the clear indication that the role of ICF for these channels is important. The present work is done to investigate the EFs of many different reaction channels in $^{16}O+^{93}Nb$ system. The measured excitation functions of 13 channels are found in well agreement with earlier measured EFs by A. Sharma et al. [5]. To the best of our knowledge the excitation function for the channel $^{93}Nb(O,2\alpha p3n)^{97}Ru$ has been reported for the first time. However residues having relatively shorter half lives could not be identified due to limitation of the activation technique.

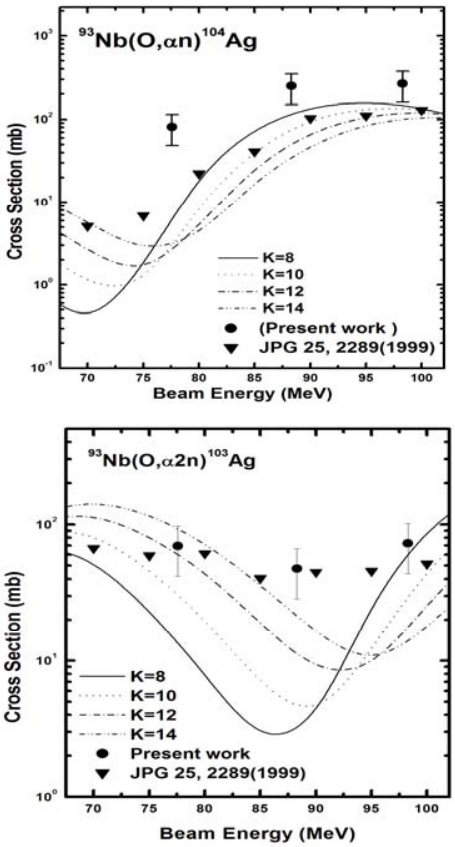

Fig. 2 Experimentally measured and theoretically calculated EFs for residues populated via (αn) and (α2n) channels in $^{16}O+^{93}Nb$ system

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