Observation of fission-like events in ^{18}O+^{159}Tb system at energy ≈ 6 MeV/nucleon

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Comprehensive understanding of heavy-ion (HI) reaction dynamics at near barrier energies has been a topic of current interest during the last few years [1–6]. Reactions induced by HIs are important, as both the projectile and target nuclei are heavy, hence large input angular momentum is involved and, therefore, the composite system can be produced with relatively high spin. Since, the de-Broglie wavelength associated with incident HIs is comparable to the nuclear dimensions, therefore, the interaction shows the semi-classical features. Thus, on the basis of driving input angular momenta (ℓ) imparted to the system, the reactions may be categorized broadly into complete fusion (CF), for $\ell \leq \ell_{crit}$, and incomplete fusion (ICF), for $\ell \geq \ell_{crit}$. The resultant composite system formed via CF and/or ICF may attain thermodynamic equilibrium and de-excite via the emission of light nuclear particle(s) and characteristics γ-rays. It may, further, be pointed out that the excited composite system may also undergo the fission depending on the available excitation energy, angular momentum, entrance channel mass asymmetry, etc. Nishio [1] has also reported that fission of incompletely fused composite nucleus is one of the dominant processes other than the fission of the composite system formed via CF at intermediate energies. The development of future nuclear power reactors with applications of hybrid technologies using accelerator based systems [7] require knowledge of precise experimental cross-sections for wide range of energy and projectile-target combinations. The experimental data for such fusion-fission reactions in HI-interaction is still limited and a comprehensive understanding of HI-induced fission at medium energies is still lacking.

In view of the above, experiments have been performed for ^{18}O+^{159}Tb system at the Inter-University Accelerator Centre (IUAC), New Delhi, India using the recoil-catcher activation technique followed by off-line γ-ray spectroscopy. Self supporting samples of isotopically enriched ^{159}Tb of thickness ≈ 1.5 mg/cm^2 were backed by Al-catcher foils. The irradiations were carried out in the General Purpose Scattering Chamber (GPSC) having an in-vacuum transfer facility. The activities induced in the samples were recorded by counting each target alongwith the catcher foil, using a pre-calibrated HPGe γ-ray spectrometer coupled to a CAMAC based CANDLE software. Our earlier studies of the ^{18}O+^{159}Tb system [5, 6] indicated that CF and/or ICF are the dominant processes for the system at energies ≈ 5-7 MeV/nucleon. Further, analysis of the present system shows the presence of several residues which are not expected to be populated either by CF or ICF processes. Moreover, these residues were found to have charge and atomic mass val-

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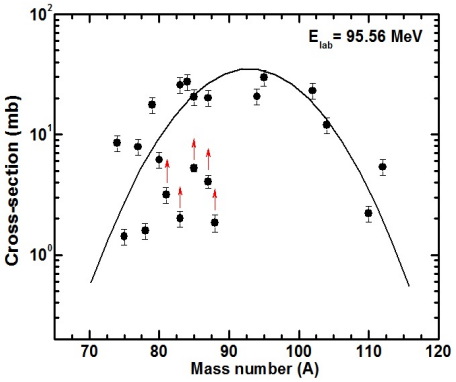

FIG. 1: (color online) Mass distribution of fission products in ^{18}O+^{159}Tb reaction at $E_{lab} \approx 95.57$ MeV (arrows indicate values expected to go up). The lines are drawn through the data points for Gaussian fit.

ues around half of the values for the residues produced by CF and/or ICF channels, indicating the possibility of their production through fission of the composite system formed via CF and/or ICF processes. Therefore, attention has been paid to identify the fission-like events after CF and/or ICF processes. More than 20 fission-like residues ($32 \leq Z \leq 40$) have been identified in ^{18}O+^{159}Tb interactions at $\approx$ 95.57 and 99.16 MeV incident energies. The total production cross-sections for the presently measured fission fragments are found to be $\approx$ 246 and $\approx$ 345 mb, at 95.57 and 99.16 MeV, respectively. It may, however be pointed out that these measured values for the total fission cross-section give only a lower limit as many fission fragments could not be observed in the present work because either they are stable or having short half-lives.

The mass distribution of fission products is one of the important observables, which is directly related to the collective dynamics of the processes. The measured mass distribution of fission fragments have been found to be symmetric, as expected. As a representative case experimentally measured mass-distribution of fission-events at $\approx$ 95.56 MeV incident energy is shown in Fig.1. It should, however, be pointed out that in the present work the fission fragments which recoil in the backward direction are lost and no correction for this could be applied. However, if catcher foils are put at both sides of the target, then both the fragments of a particular fission event in forward as well as in backward directions may be trapped and identified. It is observed that, if activities of backward and forward catcher foils are measured then more symmetric mass distribution can be achieved. Further, only the metastable states of some isotopes have observed, hence, cross-sections are expected to go up which is indicated by upward arrows. Furthermore, the isotopic yield distributions have also obtained, and matching with the literature values for other fissioning systems in this mass-region. The present measurements at such low energies ($\approx$ 6 MeV/nucleon) indicate that apart from CF and CF processes[5, 6], fission of the excited composite system is also quite significant. As such, contributions of fission should also be taken into account while predicting the total reaction cross-sections. The details of the work will be presented during the conference.

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