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Observation of fission residues in the ^{16}O + ^{181}Ta system at E_{lab} ≈ 6 MeV/A

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Abstract. Present paper reports on the production cross-section of 24 fission like events (30 ≤ Z ≤ 60) formed via complete fusion-fission and/or incomplete fusion-fission processes in ^{16}O+^{181}Ta system at energies ≈ 6 MeV/A. Experiments have been performed using the recoil-catcher technique followed by off-line γ-spectroscopy. The measured cross-section of fission-like events is satisfactorily described by a statistical model code. Further, an attempt has been made to study the mass and isotopic yield distributions of fission fragments. The variance of the presently measured isotopic yield distributions has been found to be in agreement with the literature values for some other fissioning systems.

1 Introduction

Study of the interplay of fusion-fission processes in the heavy ion reactions has been an active area of investigation during the last decade. However, recent experimental data indicates the presence of nuclear fission even at low energies where the fusion is expected to be dominant [1-2]. On the basis of driving input angular momenta imparted into the system, the reactions may be categorized broadly into complete fusion (CF) and incomplete fusion (ICF) processes. Details of CF and/or ICF processes are given elsewhere [3]. Depending upon the beam energy and entrance channel mass asymmetry the compound nucleus formed as a result of CF and/or ICF may produce fragments which are characterstics of fission process. This is generally, referred to as complete fusion-fission (CFF) and/or incomplete fusion-fission (IFF). Nishio [4] 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 at intermediate energies. It has relevance in view of the fact that one of the most important observations in earlier studies was the discovery of asymmetric mass distribution in low energy fission of the majority of the actinides [5]. The asymmetric mass distribution may be explained on the basis of nuclear shell effects. Asymmetry in mass distribution decreases with the increase in excitation energy. In view of the above, the study of the dynamics of heavy ion (HI) collisions [6,7] and systematic studies of the competition of various reaction processes which contribute to the total cross sections are of considerable importance.

In order to study the dynamics of the processes in the ^{16}O + ^{181}Ta system, a programme has been undertaken by our group. In the first part of the experiment, excitation functions for a large number of reactions in this system were analysed to study the CF and ICF processes in the energy range ≈ 76-100 MeV [8]. Further, experimental study for the same system has been done to interpret the competition between CF and/or ICF through recoil range distribution (RRD) measurements [8]. A part of the data analysis involving observation of fission events is reported in this paper. To the best of our knowledge these measurements in the ^{16}O+^{181}Ta system have been done for the first time.

2 Experimental Details

Experiment has been performed using $^{16}O^{7+}$ beam from 15UD pelletron accelerator at the Inter-University Accelerator Centre (IUAC), New Delhi, India. The thin target foils of isotopically pure (99.9%) Tantalum and Al-catchers were prepared using rolling technique. The thickness of each target and catcher foil was determined by α-transmission method. The thicknesses of the samples were determined from the observed change in the energy of the α-particles by using standard stopping power values [9] and were found to be ≈ 1.5 mg/cm^2 for Ta-targets and ≈ 2.0 mg/cm^2 for Al-catchers. The

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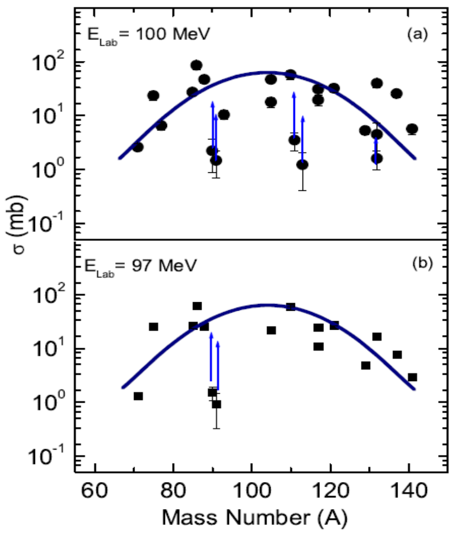

Fig.4. The plots of experimentally determined production cross-sections of various fission fragments at two different energies.

fragments. The value of σ_F^T at ≈ 97 and 100 MeV beam energies are found to be ≈ 315 mb and ≈ 500 mb. The total fission cross-section has also been theoretically estimated using statistical code ALICE [19], which employs a rotating liquid drop model [20]. The calculated σ_F^T values are found to be ≈ 500 mb and ≈ 680 mb at energies 97 MeV and 100 MeV, respectively which is in reasonable agreement with the experimentally measured fission cross-sections. Gilmore *et al.* [21] has also measured total fission cross-section for the same system employing emulsion technique. From the analysis of their data [21] they obtained the total fission cross-sections ≈ 300 mb and ≈ 430 mb at 97 MeV and 100 MeV, respectively which, in general, agree within experimental errors to the values obtained in the present work. However, it may be pointed out that the resolution and the detection efficiency of the present measurements are significantly better than that of earlier work [21].

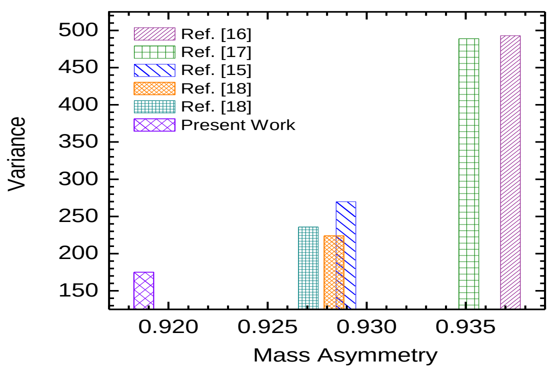

Fig.5. Bar diagram of mass asymmetry vs variances for same projectile and different target combination.

4 Summary and Conclusions

In the present work several fission fragments populated via CFF and/or IFF processes in $^{16}O+^{181}Ta$ system at 97 MeV and 100 MeV have been identified and their production cross-sections have been obtained. The data has been analyzed to deduce parameters of isotopic yield distributions. Mass distribution of fission fragments has also been obtained. The isotopic yield distributions are satisfactorily reproduced by Gaussian distribution. The distribution parameters obtained from the present measurements agree reasonably well with the literature values. The total fission cross section obtained from the present measurements agrees with some earlier measurements as well as with those calculated using angular momentum dependent rotating liquid drop fission barrier. An online experiment employing the fission detectors, by measuring the neutron multiplicity using the neutron array setup is proposed to get a detailed insight of fission dynamics for the system.

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