Fission-like events in the ^{12}C+^{197}Au system

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Introduction

The involvement of multiple nucleons in the heavy-ion-induced reaction makes it an excellent tool for studying different nuclear reaction processes, such as pre-equilibrium (PEQ) emissions, complete and incomplete fusion (CF and ICF), and fusion-fission. During the fusion process, the heavy projectile merges with the heavy target forming a heavy composite nucleus. Finally, an excited compound nucleus (CN) is formed after getting equilibrated in all degrees of freedom, which pre-dominantly deexcites through evaporating particles or fission. The process involving splitting CN into two fragments is known as fusion-fission. The residues populated during this process have their masses around half of the mass of the CN.

The investigation of fission-like events in heavy-ion-induced reactions has been a topic of great interest. Many targets and projectile combinations have been used to investigate the fusion-fission process within the 5–7 MeV/nucleon energy range [1, 2, 3]. The mass distribution of the fission fragments is an essential post-fission observable, and its variation with the excitation energy has been studied widely.

In this report, we have identified fission-like events at two incident energies for ^{12}C+^{197}Au system. Further, the variance information has been extracted from the fission fragment mass distributions (FFMDs) after fitting with a single Gaussian.

Experiment

The ^{12}C-ion beam having energy within 44-73 MeV was utilized from the 14UD BARC-TIFR Pelletron Accelerator facility, Mumbai, India. Self-supporting ^{197}Au targets having a thickness of 3.5 mg/cm^2 were prepared using the rolling method. As a backing, an Al foil having a thickness within 1.5–1.8 mg/cm^2 was placed behind each Au foil. Off-beam γ-spectroscopy method was used to assay each Au-Al set using a precalibrated large volume high purity germanium detector coupled with a PC-based multi-channel analyzer and GENIE-2K software. The populated residues (fission fragments) have been identified through their characteristic γ energies. Further, the cross section corresponding to each residue has been calculated using the activation formula, available in ref. [2].

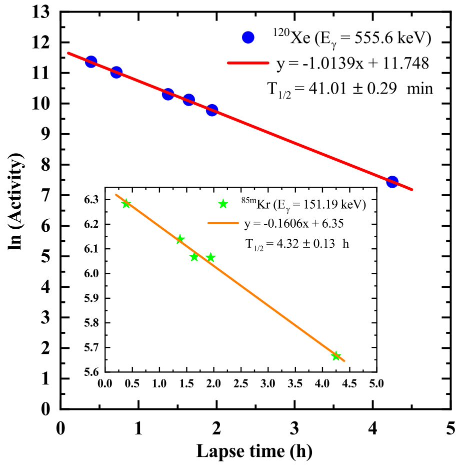

FIG. 1: Half-life estimations for ^{120}Xe and ^{85m}Kr residues.

Results and discussions

In the present system, a total of 9 radionuclides, namely, ^{85m}Kr, ^{95}Ru, ^{109}In, ^{117}Sb, ^{120}Xe, ^{129m}Ba, ^{156}Ho, ^{163}Tm, and ^{167}Ho, having a mass range within $85 \leq A \leq 167$ have

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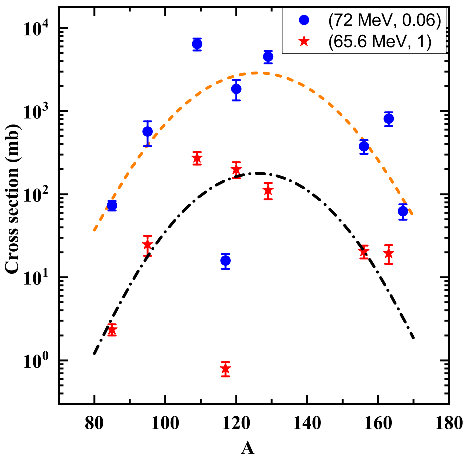

FIG. 2: FFMD at different energies obtained in ^{12}C+^{197}Au reaction. The E_{lab} and scaling factors are given in parentheses.

been identified from the γ spectra which were obtained from the irradiated target-catcher foil sets. These residues were assumed to be fission fragments with an atomic mass around half the CN. Later, the half-life estimations were carried out to confirm the identified residues. Figure 1 represents the decay profiles of ^{120}Xe and ^{85m}Kr. The half-life was found to be 41.01 ± 0.29 min for ^{120}Xe and 4.32 ± 0.13 h for ^{85m}Kr, which is close to their actual half-lives of 40 min and 4.48 h, respectively [4].

Figure 2 represents the measured cross section as a function of mass number (A) for each fission fragment at energies 72 MeV and 65.6 MeV. The sum of individual fission fragment cross sections gives the total fission cross section at a particular energy. The fission cross section was found to be 883.4 ± 85.1 mb at 72 MeV and 653.6 ± 69.3 mb at 65.6 MeV. It is important to note that for ^{129m}Ba, relative intensity instead of absolute intensity has been used for cross section calculations. It is evident from Fig. 2 that the mass distribution of the fission fragments is grossly fitted by a single Gaussian, an expected feature of the compound nuclear fission. Hence, the broad and symmetric mass distribution observed at both energies indicated the formation of the fission fragments through the compound nuclear mechanism.

Moreover, dispersion parameters like most probable mass (M_p) and width parameter (σ_m) have been extracted from the FFMDs obtained at both the energies and represented in Table I. It can be observed from the table that as we go to the higher energy, the width parameter increases, i.e., there is a broadening of FFMD with increasing excitation energy of the CN (E^*).

TABLE I: Dispersion parameters for both the energies.

$E_{lab}(MeV)$	$E^*(MeV)$	M_p (u)	σ_m (u)
72	49.6	126	15.5
65.6	43.6	126	14.5

Conclusion

During the fusion of ^{12}C projectile with ^{197}Au target, the production of 9 fission fragments was observed and later confirmed through the half-life measurements. The FFMDs were found to be broad and symmetric. This observation indicated their production through the CN's deexcitation. The mass width was found to be increasing with the excitation energy.

Acknowledgments

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