Measurements of fission fragment cross-section in ^{14}N + ^{175}Lu system at lower energies

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Introduction

The study of heavy-ion (HI) induced reactions [1] has been a significant area of interest of research in the experimental nuclear physics. In HI interactions, fission is one of the reaction mechanisms at relatively higher excitation energies. Recent experimental data indicate the presence of fission even at lower energies, where fusion is expected to be dominated. Theoretical and experimental investigations reveal that fission is a competing mode with the fusion at low incident energies below 10 MeV/nucleon. In such reactions, the compound nuclei (CN) formed via complete fusion (CF) or incomplete fusion (ICF) [2] of projectile with target nuclei can undergo fission, provided the proper values of the excitation energy and angular momentum.

In the case of CF, compound nucleus (CN) is formed after transferring the full momentum from the projectile to the target nucleus undergoes fission, the process is termed as complete fusion-fission (CFF). Alternatively, when there is incomplete momentum transfer to the CN and it decays via fission is called as incomplete fusion-fission (IFF). Several attempts have been made to explain HI-induced fission reactions, however, a comprehensive understanding remains elusive. A more systematic investigation involving different projectile and target combinations is required. The present study explores the dynamics of the fusion-fission process via CF, and ICF in the system ^{14}N + ^{175}Lu at low incident energies varying near the Coulomb barrier to 88 MeV.

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Experimental details

The experiment was conducted at the Inter-University Accelerator Centre (IUAC) in New Delhi, India. In these experiments, the ^{175}Lu target sandwiched within the thick aluminum foil was bombarded by a ^{14}N beam in the General Purpose Scattering Chamber (GPSC) at diferent energies 72, 76, 80, 84 and 88 MeV, respectively. The activities induced in the target-catcher assemble were recorded employing the offline γ spectroscopy at various time intervals with a high-purity germanium (HPGe) detector with a 100 cm^3 active volume.

Data analysis and results

In order to measure the cross-section of fission-fragments, the residues have been identified primarily with the characteristic γ ray and then they are further confirmed with the decay curve analysis by determining their half-

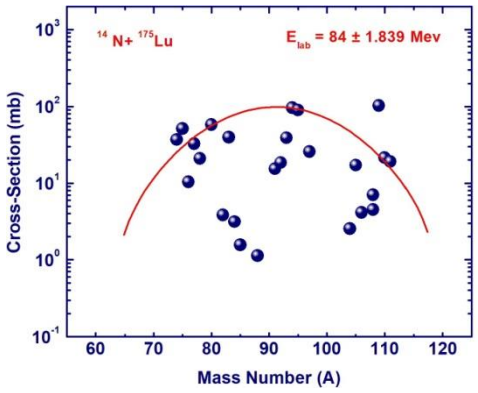

FIG. 1: Mass distribution of fission-like events populated via complete fusion-fission and/or incomplete fusion-fission processes in the ^{14}N + ^{175}Lu system at 84 MeV .

lives. Intensity of fission-fragments is converted into the cross-section σ_Z by using the standard formulation [3].

The mass distribution of fission fragments is crucial parameter in the study of fission observable which links to the collective dynamics of fusion-fission processes. The variation of the width of the fission fragment mass distribution with excitation energies of the compound system is an important probe for studying the different types of fission processes, such as statistical fission, fast fission, pre-equilibrium fission and quasi-fission [4]. As a typical example, the mass distribution of fission-fragments in the ^{14}N + ^{175}Lu system at E_{lab}= 84 MeV is shown in Fig 1. The mass distribution is found to be symmetric and can be fitted with one Gaussian function. This indicates that, the formation of these fission fragments after forming an equillibrated compound nucleus.

Further, the isotopic yield distributions of Bromine (Br) and Krypton (Kr) fission-fragments have been observed and are shown in Fig. 2. Their measured production cross-sections have been accurately fitted with single Gaussian distribution referring their productions from the equilibrated CN.

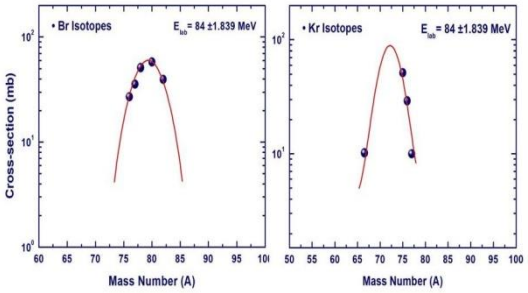

FIG. 2: Isotopic yield distribution of Bromine and Krypton isotopes is the Gaussian fit.

Conclusions

In the present work, the production cross-sections of 25 fission-like residues in ^{14}N + ^{175}Lu system 74 ≤ A ≤ 111 have been measured at the ≈ 70-88 MeV. The mass distribution of fission fragments fits well with a Gaussian distribution, centered around half the mass number of the compound nucleus ^{189}Pt*, indicating fission occurs after the compound nucleus reaches equilibration. Further details regarding the competition between fusion and fission will be presented.

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References

[1] A.V.Andreev et al., Phys. Rev. **C 86**, 044315 (2012).
[2] M.K. Sharma et al, Phys. Rev. **C 94**, 064617 (2016).
[3] Mohd. Shuaib et al., Phys. Rev.**C 98**, 014605 (2018)
[4] A. Chaudhuri et al, Phys. Rev. **C 94**, 024617 (2016).