Isotopic yield and mass distributions of neutron-rich fragment nuclei produced in α induced fission of ^{232}Th

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Introduction

Nuclear fission, a sufficiently complex process involving large scale collective rearrangement of nuclear matter in a short time scale, continues to generate a lot of research interest even after more than seventy-five years of its discovery. The fission fragment nuclei that are produced in a fission process, present considerable challenges to researchers due to their higher neutron-to-proton ratios. However, the relative production yields of these fragment nuclei change from one fissioning system to another. Also, the complementary fragment partners (charge pairs) differ in different fissioning systems. For a same compound fissioning system at different excitation energies, the relative isotopic and mass distribution profiles vary, and this provide valuable information on the nuclear fission process.

Prompt γ spectroscopic studies of neutron-rich fission fragment nuclei provide direct information on their relative production yields. In addition, employing prompt γ-γ coincidence technique, excited states of these nuclei can be studied. Such studies have been helpful in exploring several exotic nuclear phenomena, evolution of dynamic shell structures, and even new magic numbers.

A lot of work has already been carried out on fission fragment nuclei, and their relative isotopic yield and mass distributions using ^{252}Cf, ^{248}Cm spontaneous fission (SF) sources, heavy-ion induced fusion-fission reactions and thermal neutron induced fission of fissile targets. Recently, experiments on thermal neutron induced fission of ^{235}U target have been carried out at CIRUS reactor facility, BARC [1], and at the high-flux reactor facility at Institut Laue-Langevin (ILL), Grenoble, France. Results on relative isotopic yield distribution from the CIRUS measurement have already been published [1].

Here we report the results obtained from prompt γ-γ coincidence measurement in ^{232}Th(α,f) reaction. This will essentially provide us to perform a comparative study of the fragment nuclei and their relative yield for the same compound fissioning system (^{236}U) at a different excitation energy.

Experimental details

The experiment was carried out at Variable Energy Cyclotron Centre, Kolkata. Fission fragment nuclei were produced and populated at higher excitation energies when 30 MeV α particles from the cyclotron bombarded a self-supporting ^{232}Th target of thickness $\sim$25 mg/cm^2. Deexciting γ rays from the neutron-rich fragment nuclei were detected using the Indian National Gamma Array (INGA) spectrometer which comprised of six Compton suppressed clover Ge detectors and one LEPS detector. Out of the six sup-

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pressed clover Ge detectors, four were at 90°, and the remaining two were at 125° angle with respect to the beam direction. The LEPS detector was mounted at 40° with respect to the beam direction. A digital signal processing based data acquisition system, employing Pixie-16 digitizers from XIA-LLC, USA, was used to acquire time-stamped, Compton suppressed, two- and higher-fold coincidence data, which were subsequently analyzed offline, using the RADWARE and TV software packages.

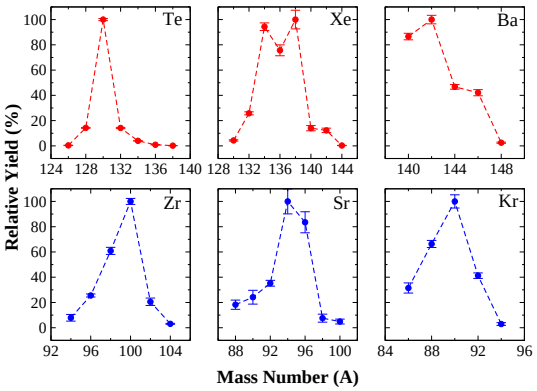

FIG. 1: Isotopic yield distribution of complimentary fission fragment nuclei as obtained from the data.

Results and discussion

Symmetric γ-γ matrix was constructed from the acquired data set after proper energy calibration followed by software gain matching over the entire range of energy. The analysis of γ-γ coincidence matrix has revealed the population of several complimentary fragment pairs. The relative isotopic yield distributions of even-even isotopes of a few complimentary charge pairs (*viz.*, Zr-Te, Sr-Xe, Kr-Ba) have been obtained (Fig. 1).

The detailed relative isotopic yield distributions of even-even, odd-Z, odd-N, and odd-odd isotopes, when summed together for a particular mass number, would present the relative mass yield for that particular mass number in this fusion-fission reaction. Fig. 2 shows

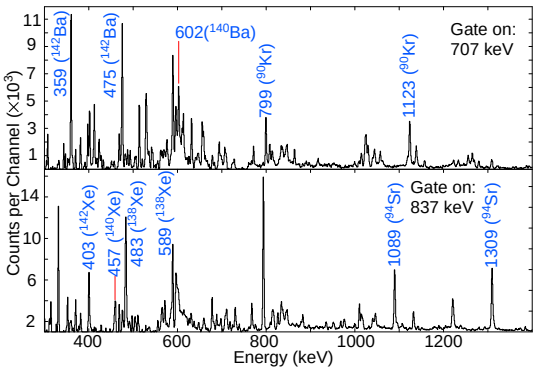

FIG. 2: Representative gated spectra of ^{94}Sr (lower panel) and ^{90}Kr (upper panel). A few strong transitions of ^{94}Sr, ^{90}Kr, and their complementary fragments are labeled.

representative gated spectra for the ^{94}Sr and ^{90}Kr isotopes as obtained from the γ-γ coincidence matrix. The strong γ transitions of complementary fragment nuclei are also evident in the spectra in addition to the γ transitions of the above mentioned nuclei. From such spectra, the coincidence rates of isotopes are being measured. Additionally, the mean fragment angular momenta of even-even fission fragments are being extracted using the method described in Ref. [1]. Analysis on all these aforesaid aspects are in progress, and results in detail will be presented during the symposium.

Acknowledgments

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References

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