Determination of Fission Product Yield for Lifetime and Quadrupole Moment Measurement

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Introduction

An experimental program on the systematic measurement of lifetime and quadrupole moment of different fission product isotopes has been taken up by a joint effort of Radiochemistry Group, VECC and Physics Group, VECC. Presently, such measurements are being performed with the neutron rich Tellurium (Te) -isotopes which could be populated with reasonable cross section from α-induced fission of ^{238}U [1, 2]. The decay spectroscopy of Te isotopes ($t_{1/2}$ ~ 1h to 3.3d) was used to study the n-rich Iodine (I) and Xenon (Xe) nuclei around the double shell closure of ^{132}Sn. As the study involves the radiochemical separation of the radioisotopes of interest from the rest of fission products, the measurement of half-lives as well as isotopic yield of different fission products is of major importance in the present case. This information around the two humps of the fission mass distribution curve could also be helpful to explore the possibility of such kind of study in future.

So far the literature shows, there has been a number of works on the fission study of ^{238}U. Among them, most of the works involves either neutron induced fission [3, 4] or photo-fission [5]. The information on mass distribution inα-induced fission of ^{238}U is still scanty [6].So, our primary objective in the present work is to identify the radionuclides produced in the α-induced fission of ^{238}U at different projectile energies and then measure the yield of different suitable radioisotopes. Finally, the radioisotopes would be radiochemically separated for subsequent lifetime and quadrupole moment measurement with VENTURE array consisting of fast scintillator detectors developed at VECC, Kolkata [7]. The present work describes the α-induced fission experiment on ^{238}U using 30MeV α-beam delivered from K=130 Cyclotron at VECC, Kolkata and identification of some of the radioisotopes produced in the fission reaction.

Experiment

The fission reaction was carried out with U-targets prepared by electro-deposition. The thickness of the target was ~750μg/cm^2. A 30MeV α-beam at a current of ~500nA was used for the reaction. After irradiation, the U-target was counted with a setup of two Clover HPGe detectors and a low energy photon spectrometer (LEPS) as shown in Fig. 1. The distance between U-target and detectors was kept to be ~5cm. One of the Clover detectors was placed at 90^o and the other at 180^o with respect to the LEPS detector. The pulse processing was done with standard NIM electronics and the data acquisition was performed using VME based data acquisition system. Both counting and analysis was performed with LAMPS [8] software. The counting was performed in batch mode and followed over duration of ~130 days in order to identify radionuclides of longer half- lives (days to months).The direct counting of the irradiated U-foils were performed after a cooling period of 1d in order to allow shorter-lived fission products to decay out. After that, the foils were counted in singles and coincidence mode with the three detector setup as shown above.

Results and Discussion

The addback spectrum obtained at different time with one of the Clover HPGe detectors of the setup is shown in Fig. 2. The spectra taken after different time intervals from the end of irradiation, viz., after 40h and 10d are significantly different indicating the population of nuclei with a long range of half- lives. The energy of the transitions along with the possible origin has been indicated in the figure.

Fig. 1: *Experimental setup used in the present work.*

Several fission products have been identified by following their decay γ-lines and the corresponding half-lives. Many of the γ-transitions were also found to follow a composite curve consisting of growth and decay. Some of the transitions, marked with * in Fig. 2, are yet to be identified from coincidence analysis.

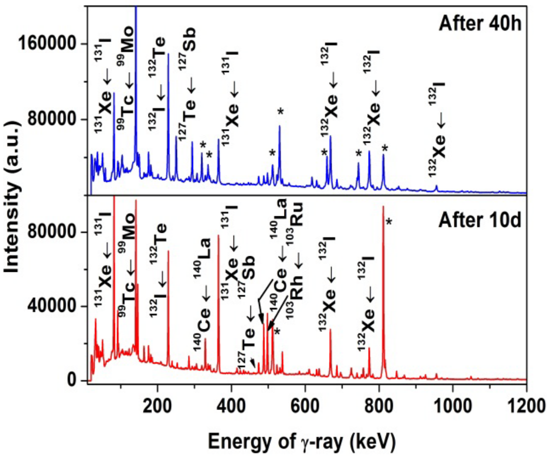

Fig. 2: Evolution of γ-spectrum with time. Some of the identified peaks are marked.

Some representative decay plots for ^{99}Mo (2.75d), ^{127}Sb (3.85d), ^{132}Te (3.26d) and ^{131}I (8.02d) are shown in Fig. 3. This observation indicates the possibility of lifetime and quadrupole moment measurements in many of the n-rich nuclei in the A~100 and A~130 region. The determination of cumulative yield of several isotopes would be attempted to present during the symposium.

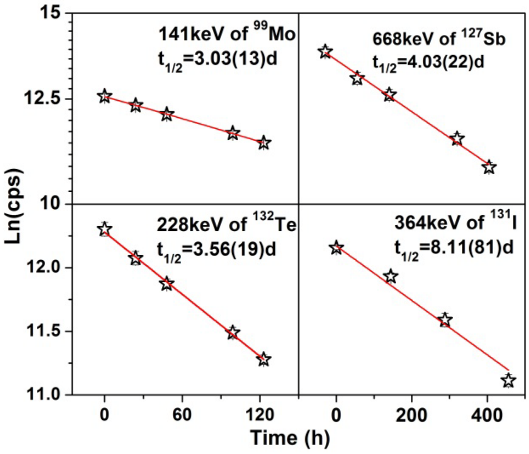

Fig. 3: Decay plots for different γ-lines

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