Fission Products Yield In the Neutron-Induced Fission of ^{238}U With Average Neutron Energy of 11.85 MeV

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Measurement of fission product yields from fission of ^{238}U targets with incident neutron energy of 11.85 MeV is reported. The measurements were carried out using activation and off line gamma ray spectroscopic techniques. The fission yields values are reported for about twelve fission product nuclides. The neutrons were generated using the ^{7}Li (p, n) reaction at BARC-TIFR Pelletron facility, Mumbai, Activated targets are counted in highly shielded HPGe detectors over a period of several weeks to identify decaying fission products The results obtained from present work have been compared with the similar data of mono-energetic neutrons of comparable energy from literature and are found to be in good agreement..

The experiment was carried out at TIFR-BARC Pelletron facility at the 6 meter height main line [1] About 1.0 cm^2 of ^{238}U metal foil with thickness 30.0 mg/cm^2, doubly wrapped with 0.025 mm thick Al foil was mounted at zero degree with respect to the beam direction at a distance of 2.1 cm from the location of the Ta-Li-Ta stack. The^{238}U metal foil was irradiated for 12 hours at 11.85 MeV quasi mono-energetic neutrons by using ^{7}Li(n, p) reaction of 16 MeV proton beam. The proton current during the irradiations was 200 nA. After irradiation, the samples were cooled for one hour. Then the irradiated target of ^{238}U along with Al wrapper was mounted on Perspex plate and taken for γ-ray spectrometry. The γ-rays of fission products from the irradiated ^{238}U sample were counted in energy and efficiency calibrated 80 cm^3 HPGe detector coupled to a PC-based 4K channel analyzer. The counting dead time was kept always less than 5 % by placing the irradiated ^{238}U sample at a suitable distance from the detector to avoid pileup effects. The γ-ray counting of the sample was done in live time mode and was followed as a function of time.

The photo-peak areas of different γ-rays of interest were calculated by subtracting the linear background from their net peak areas. The number of γ-rays detected (A_{obs}) under the photo-peak of each individual fission products is related to the cumulative yield (Y_c) with the following relation,

$$A_{obs}(CL/LT)=N\sigma_f(E)\varphi I_\gamma \varepsilon Y_c(1-e^{-\lambda t})e^{-\lambda T_c}(1-e^{-\lambda LT})/\lambda \quad (1)$$

Where, N= number of target atoms,
$\sigma_f(E)$ = neutron-induced fission cross-section as a function of neutron energy (E) of the target with average neutron flux (φ)
I_γ= branching intensity for the γ-ray of the fission product, ε = efficiency
t = irradiation time, T_c= cooling time
CL and LT = clock time and live time of counting, respectively

The nuclear spectroscopic data such as the γ-ray energy, branching intensity and half-life of the fission products are taken from ref. [2]. The cumulative yields of the fission product relative to fission rate monitor ^{97}Zr were calculated using eq. (1). The yield of fission rate monitor ^{97}Zr was chosen from the point of view of the near constant yield with change of neutron energy.

The cumulative yields of twelve fission products in the 11.85 MeV neutron-induced fission of ^{238}U along with nuclear spectroscopic data are given in Table 1. The uncertainties associated to the measured cumulative yields come from the replicate measurements. The overall uncertainty is the quadratic sum of both statistical and systematic errors.

The yields of fission products from the present work in the 11.85 MeV neutron induced fission of ^{238}U are plotted in Fig. 1 along with the literature data of 14 MeV [3]. The double humped nature of the yield distribution in 11.85 MeV neutron induced fission of ^{238}U is clearly seen from Fig. 1. It can be also seen from Table 1 and Fig. 1 that most of the yields of the asymmetric fission products are in good agreement with the literature data except for ^{129}Sb. For the symmetric product ^{115}Cd, the fission yield at neutron energy of 11.85 MeV is also lower than the similar data at 14 MeV. This is expected because the peak-to valley ratio increases with decrease of neutron energy.

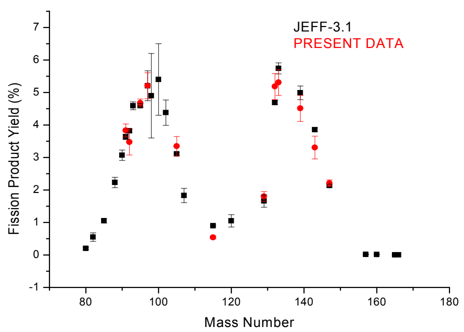

Fig.1. Plot of fission products yields for ^{238}U at average En = 11.85 MeV compared to 14 MeV from ref. [3].

Table-1

Yields of fission products in the 238U fission at En = 11.85 MeV. (Yield of Zr-97= 5.206% from the 14 MeV neutron induced fission of 238U was taken as reference)

Nuclides	Cummulative Yield (%) of the measured Fission products	Joint Evaluated Fission and Fusion File, Incident neutron data, http://www-nds.iaea.org/exfor/endf00.htm, 2 October 2006; see also A. Koning, R. Forrest, M. Kellett, R. Mills, H. Henriksson, Y. Rugama, The JEFF-3.1 Nuclear Data Library, JEFF Report 21, OECD/NEA, Paris, France, 2006, ISBN 92-64-02314-3.
Sr-91	3.831± 0.2	3.635 ± 0.084
Sr-92	3.476± 0.4	3.820 ± 0.057
Zr-95	4.687± 0.12	4.594 ± 0.056
Zr-97	5.206 ± 0.4	5.206 ± 0.046
Ru-105	3.346± 0.3	3.109 ± 0.047
Cd-115	0.54± 0.05	0.900 ± 0.025
Sb-129	0.94 ± 0.15	1.66 ± 0.19
Te-132	5.184 ± 0.4	4.690 ± 0.066
I-133	5.31± 0.4	5.74 ± 0.17
Ba-139	4.51 ± 0.4	4.99 ± 0.21
Ce-143	3.306± 0.35	3.855 ± 0.058
Nd-147	2.209± 0.10	2.134 ± 0.041

We are thankful to the staff of BARC-TIFR Pelletron facility for their excellent assistance during experiment.

References

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