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Measurement of an effective mass attenuation coefficient for fission fragments in uranium targets

R K Jain, S K Bose and J Rama Rao
Department of Physics, Banaras Hindu University, Varanasi-221 005, India

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Abstract : The paper describes a method for measuring mass attenuation coefficient for fission fragments in uranium in connection with the study of their tracks observed in a solid state nuclear track detector viz Lexan Different thicknesses of the fissile material were deposited on Lexan plastics and irradiated to thermal neutrons to induce fission The track density, T, has been found to be related to the mass of the fissile material, m, through the equation $T = C me^{\mu m}$, where C is a constant and μ = mass attenuation coefficient

Keywords : Fission, solid state nuclear track detectors, mass attenuation coefficient, track density.

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The response of a fission detector closely follows the fission cross section modified by self scattering and self-absorption of fission fragments in the fissile material and consequent registration efficiency variation (i.e. fraction of fission fragments detected). Solid state nuclear track detectors are now-a-days being used in a quantitative study of fission fragments. This type of work is mostly done by using special type of SSNTDs, e.g. Lexan, as the medium for collecting tracks of fission fragments [1]. The present work is motivated to measure an effective mass attenuation coefficient for fission fragments in uranium in the well studied thermal neutron induced fission of ^{235}U. Different thicknesses of the fissile material are deposited on Lexan plastics and irradiated to known neutron fluences. The track density measured is then related to the mass of the material deposited on the Lexan detector through the equation [2]

$$T = C\, me^{\mu m} \tag{1}$$

where T is the track density, m is the mass per unit area fo the material and C and μ are constants; the constant C is the required track density per unit mass for an infinitely thin target ($m \to 0$), while μ represents an "effective mass attenuation coefficient" for self absorption as well as self scattering effects.

Several pieces (1 cm × 1 cm) of Lexan plastics were cut from a sheet of uniform thickness (~ 200 um). The fissile material solution of uranyl nitrate was prepared by dissolving one gram of the material in 10 c.c. of distilled water. A known amount of the fissile material was deposited on each plastic detector and then dried with the help of an infrared lamp. In this way, targets of different thicknesses were prepared. Then the Lexan pieces coated with fissile material were exposed to the slow neutrons from a Ra-Be source for different lengths of time. The slow neutron flux was ~ 3×10^6 n cm^{-1} sec^{-1} at that point where experiments were carried out. The distance of all Lexan detectors was the same from the neutron source (Ra-Be). After irradiation the plastic pieces along with an unirradiated plastic were etched in 6.25N NaOH solution at 60°C for one hour to two hours, in a thermostatically controlled oven [3]. Etched fission tracks were counted to yield track density by viewing under an optical microscope using 600X magnification. During scanning, proper care was taken not to count the same area of the detector more than once. In each plastic foil equal area was scanned.

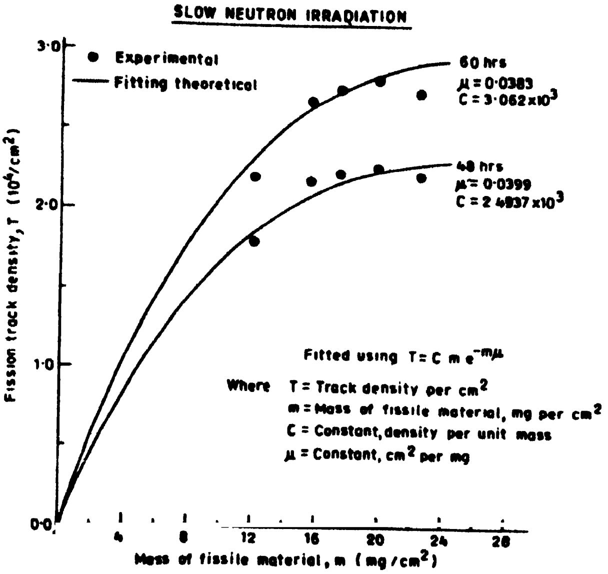

Figure 1. A plot between mass of fissile material and fission track density in the case of slow neutron induced fission of ^{235}U.

The track density measured is related to the mass of the fissile material deposited on these detectors through the eq. (1). The exponential factor indicates a process of absorption or scattering of the fission fragments in the fissile material. Figure 1 shows the curve between fissile mass vs track density. A least square fit of the experimental points was made using eq. (1), to find out the values of constants from the above figure. It may be observed that while the value of the effective absorption coefficient μ is nearly the same for the two curves, the values of C increases in proportion to the time of irradiation, as it should, because by definition, C is the track density per unit mass for an infinitely thin target ($m \rightarrow 0$). From the observation, an average value of 0.039 ± 0.001 is obtained for the effective mass attenuation coefficient for fission fragments in uranyl nitrate.

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