Study of $^{40}\text{Ar}$ ion tracks in cellulose nitrate

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Abstract. Sample of cellulose nitrate (Russian) is exposed to $^{40}\text{Ar}$ ions. The bulk etch rate has been studied at different etching temperatures and the activation energy for bulk etch rate has been calculated. The etched track lengths are measured for different etching times. The energy loss rate and range of $^{40}\text{Ar}$ ions in CN(R) is also calculated. The critical threshold value for etchable track in CN(R) is determined by comparing the theoretical and experimental values of track length. The response curve of CN(R) is also presented.

Keywords. Cellulose nitrate; chemical etching; activation energy; track length; response curve.

1. Introduction

In recent years, solid state nuclear track detectors (SSNTDs) have been used increasingly in various branches of science and technology (Fleischer et al 1975; Fleischer 1977). Track etching technique has successfully been employed in many insulating materials for revealing the path of charged particles and for their identification. SSNTDs are currently being used in the study of heavy particles, search of super heavy elements, fission fragments studies, cosmic ray studies etc. The cellulose nitrate (Russian) (CN(R)) is one of the most sensitive plastic track detectors available. The various track parameters, which can be measured experimentally, can be used for particle identification.

In this paper the tracks of $^{40}\text{Ar}$ ion of energy 7.5 MeV/N and 4.22 MeV/N at an angle of 10° with respect to detector surface in CN(R) are studied. The bulk etch rate has been measured at different etching temperatures and the activation energy for bulk etch rate is calculated. We have also measured the track etch rate $V_e$ and the range of this ion in CN(R). We have calculated the total energy loss $dE/dX$ and range of $^{40}\text{Ar}$ ions in CN(R) using the relations of Mukherji and Nayak (1979) and the value of critical threshold for track etching $(dE/dX)_c$ for this plastic has been estimated. The response of this plastic is also studied.

2. Experimental details

Samples of CN(R) with composition $C_6H_8O_9N_2$ and thickness 1000μm were exposed at JINR, Dubna, USSR to $^{40}\text{Ar}$ ions with energies 7.5 MeV/N and 4.22 MeV/N at angles
90° and 10° to the plane of the samples. The exposed samples were etched in stirred 6.25 N sodium hydroxide solution at (60 ± 1)°C. The thickness difference method was preferred for measuring bulk etch rate $V_b$ over the weight-loss method. This was because the latter method is not applicable since water absorption by the plastic (≈ 4% by weight at 70°C, Blandford et al 1969) makes it difficult to measure the dissolved weight accurately. We have also measured bulk etch rate $V_b$ by the diameter measurement technique using fission fragment of $^{252}$Cf (Rao et al 1981).

For $V_t \gg V_b$, the average diameter $D$ of fission fragment is obtained by the relation.

$$D = 2 V_b t,$$

where $V_b$ is the bulk etch rate and $t$ is the etching time.

The etch pit diameter and length were measured with a transmitted light microscope ‘Olympus’ BH (Japan) having an eyepiece micrometer whose least count = 0.215 μm at a magnification of 900 X. The $V_t$ value was calculated on the assumption that it remains constant for very small etching time during which a small segment of particle trajectory is etched (Fleischer et al 1975). The correlation between the $V_t$ and the track length for an etching time $t$, is given by relation

$$L = \int_0^t V_t \, dt,$$

$$V_t = \delta L/\delta t,$$

where $\delta L$ is the small change of track length in small etching time $\delta t$.

3. Results and discussion

Figure 1 shows the variation of log $V_b$ against $1/T$, where $T$ is the etching temperature in °K, to find out the activation energy $E_b$ for bulk etching which is found to be

![Figure 1. Plot of log $V_b$ vs $1/T \times 10^3$ (°K$^{-1}$).](image)