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ELECTROCHEMICAL ETCHING OF FISSION FRAGMENT TRACKS IN MUSCOVITE MICA AND SODA GLASS

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Electrochemical etching study has been carried out for muscovite mica and soda glass, irradiated with fission fragments of ^{252}Cf, under various electrical and etchant parameters. In case of muscovite mica, it is observed that preferential chemical etching is correlated with applied field strength and frequency. Soda glass does not exhibit any such behaviour. The investigations reveal that treeing phenomenon does not occur in muscovite mica and soda glass under the prevailing experimental conditions.

1. Introduction

Electrochemical etching (ECE) [1] provides the large scale amplification of tracks which makes it suitable for neutron dosimetry [2–5] and other applications [6–9]. The ECE technique has been successfully exploited to etch nuclear particle tracks in polymeric dielectrics such as CR-39, Lexan, Makrofol, PET, and CN available commercially.

In this paper we report a few investigations regarding the ECE response of muscovite mica and soda glass. The ECE of these materials has been carried out over a wide range of ac voltages and frequencies for different periods of time. Track parameters such as length, diameter and density have been measured. The preliminary results on optimum electrical parameters for ECE of muscovite mica are presented.

2. Experimental procedure

The muscovite mica was obtained from Nansa mine, Rajasthan state, India. Muscovite mica is a silicate mineral with a pronounced sheet structure. The bonds

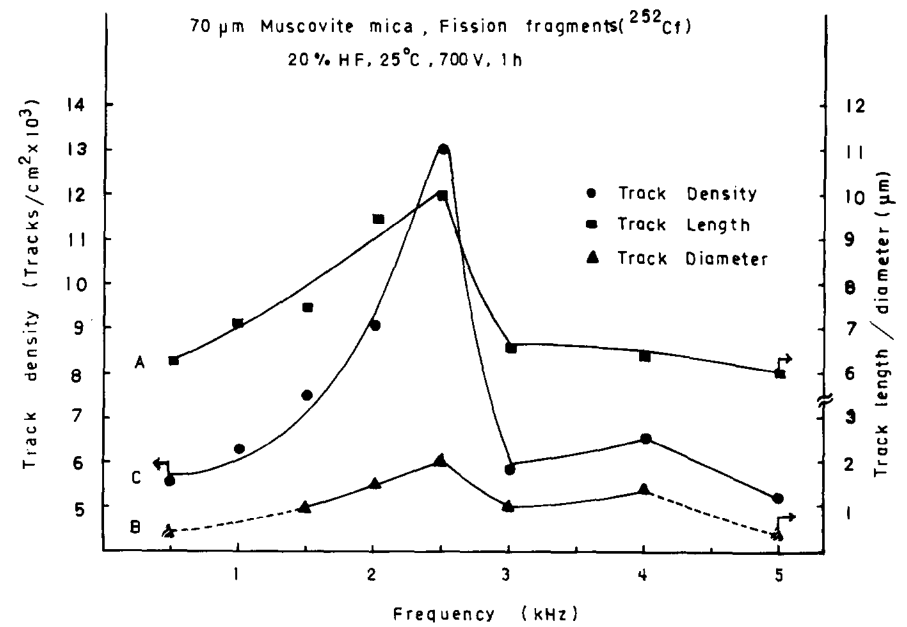

Fig. 1. Track density (left), length and diameter as the functions of frequency.

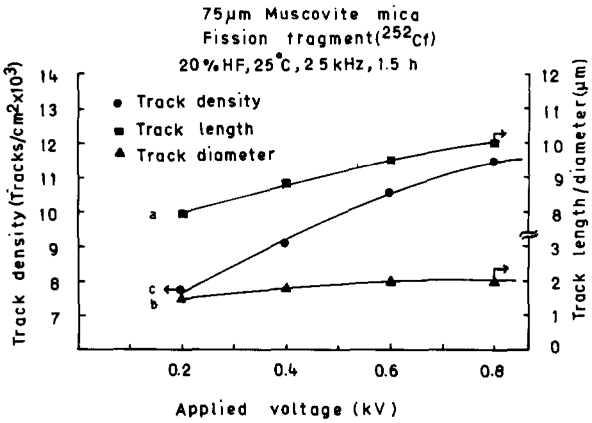

Fig. 2. Track density (left), length and diameter as the functions of applied voltage.

between the atoms within the sheets are strong while the bonds linking the adjacent sheets are weak. It is easy to cleave sheets of any thickness. A sharp punch can be used to cut circular sheets. Careful handling is essential to avoid cracks in the sheets which may lead to short circuiting during ECE. The circular glass samples were cut out of Blue Star microscopic cover glass of thickness 150 μm.

The circular sheets of muscovite mica and soda glass of 12 mm diameter were irradiated with fission fragments of ^{252}Cf in 2π geometry. These samples were electrochemically etched with HF keeping the exposed side in contact with the etchant.

For muscovite mica, HF concentration was varied from 2.5 to 40% at 25 °C applying an alternating voltage ranging from 200 to 800 V at frequencies 0.5 to 5 kHz for periods of time from 30 min to 2 h. In case of soda glass, the HF concentration was varied from 0.62 to 20% at 25 °C and an ac voltage from 200 to 1000 V was applied at frequencies 0.025 to 5 kHz for different intervals of time from 30 min to 2.5 h.

The tracks were counted and their length and diameter were measured using a Carl Zeiss binocular microscope in both muscovite mica as well as soda glass.

3. Results and discussion

Curves A, B and C (fig. 1) represent the variation of track density as well as length and diameter of tracks in muscovite mica as a function of ac field frequency. All the curves (A, B, C) show distinct resonance peaks corresponding to a frequency of 2.5 kHz. Fig. 2 represents another similar set of curves (a, b, c) obtained by varying applied field voltage from 200 to 800 V at the resonance frequency of 2.5 kHz. It is evident from the figure that ECE rate is almost a linear function of applied voltage.

Fig. 3a shows a photomicrograph of electrochemically etched fission fragment tracks in muscovite mica when ECE was carried out for 45 min. using 40% HF at 25 °C under an ac voltage of 750 V at resonance frequency. Fig. 3b is a photomicrograph of chemically etched fission fragment tracks under similar conditions. It is obvious that ECE rate is enhanced as compared to CE rate in muscovite mica.

Under the influence of electric field polar polymeric detectors exhibit the phenomenon of polar and interfacial polarizations [10] which are the main cause of ECE process. At certain field frequencies a resonance type

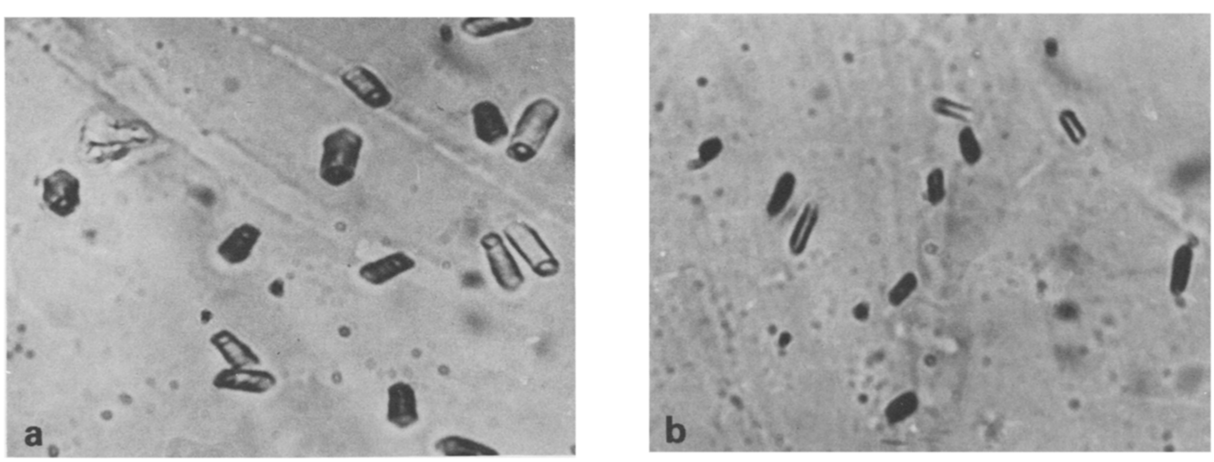

Fig. 3. Photomicrographs (at ×1000 magnification) of fission fragment tracks in muscovite mica (a) etched electrochemically: HF 40%; 25 °C; 45 min; 750 V ac; 2.5 kHz (b) etched chemically: HF 40%; 25 °C; 45 min.

effect is observed [11]. Similar phenomenon has also been detected during ECE of muscovite mica as shown in fig. 1. The exceptional rise in etch rate around 2.5 kHz shows a resonance type effect which might be due to the polar nature of muscovite mica. It is also evident from the fig. 3a that treeing did not take place with in the domain of electric parameters used during the experiment. The absence of treeing phenomenon might be due to the nonavailability of the threshold field strength at the tip of the tracks.

In the case of soda glass, no resonance effect is observed up to a frequency of 5 kHz. Photomicrographs of ECE etched tracks and chemically etched tracks under similar conditions reveal no appreciable difference in size and shape.

Soda glass being amorphous in nature with randomly arranged molecules does not produce any net polarizing effect under electric field. Hence no significant ECE enhancement is observed. Our finding is in agreement with the results reported elsewhere [12].

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