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IR Induced Modifications in Some Solid State Track Recorders

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The environmental conditions may affect the characteristics of solid state nuclear track detectors during their exposure in space. Hence, it is essential to study the environmental effect on these detectors. The effect of infrared radiations on the etching characteristics of CR-39 and glass has been reported in this paper. CR-39 plastic track detector has been found to be more sensitive to these radiations than glass.

Key Words: IR radiations, Plastic track detector, Glass, Etching rate.

INTRODUCTION

Solid-state nuclear track detectors have numerous applications in diverse fields such as radiation dosimetery, cosmic rays, heavy ion physics, microanalysis, uranium prospection, micro filters and nuclear physics[1]. It has been established that polymers are most suitable materials for recording heavy components of cosmic radiations that were known to be high-energy charged particles that entered the solar system from all directions. A precise knowledge of range, track length and energy loss rate of heavy ions in solids is of great importance to nuclear and allied scientists from practical as well as theoretical point of view to detect the cosmic ray particles that enter the earth's atmosphere. These scientific and technological applications of Solid State Nuclear Track Detectors (SSNTD's) have simulated efforts to develop better track recording solids of various relative radiation sensitivity, which depends on the properties such as composition and ionic or molecular weight of the material used as detector, on the mass and energy of the impinging ion and on the environmental conditions. Since these detectors are exposed to the open environment as such to study the cosmic rays, the radiations from the sun and the other environmental conditions like temperature and relative humidity can have significant and sometimes profound effect on the properties of track detectors[2]. Investigations of these conditions may be helpful to select a set of suitable environmental conditions under which these detectors will work most effectively.

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Among the various environmental effects, heat has a specific significance as it can repair or enhance the charge particles created damage depending on the nature of the material exposed.

The irradiation of plastic track detectors by slightly ionizing radiation can either promote cross-linking of polymer molecules causing a decrease in general etching velocity or can cut the long chain molecules, converting them into shorter, more rapidly etchable materials. Similarly it is assumed that glass detectors[3] are less prone to environmental conditions and play a special role among SSNTD's due to their applications in neutron dosimetry and fission track dating of volcanic rocks, yet the study of environmental affects on them is necessary for the better understanding of latent track formation and the variation of response of such routine dosimeter with the surrounding conditions to detect the systematic errors. In the present work an attempt has been made to study the effect of infrared radiation on the bulk etch rate and sensitivity of CR-39 and glass, the solid state nuclear track detectors.

EXPERIMENTAL

The experimental part involves the (i) irradiation; (ii) IR exposure; (iii) etching of the samples; (iv) scanning of the samples (v) measurement of the etch rates.

Irradiation

Pieces of CR-39 plastic track detector, procured from Pershore Mouldings Ltd., and microscopic glass slides manufactured by Rohem Instruments Pvt. Ltd. were irradiated with ^{252}Cf fission fragment source in 2π-geometry for twenty-four hours.

IR exposure

The above-irradiated samples were exposed with infrared radiations from an IR lamp of 150 watts kept at a height of 6 cms from the source output and at a voltage of 210 V for different time spans varying from 1 to 24 h. For comparison one sample was kept unexposed.

Etching of the samples

The CR-39 samples (exposed and unexposed) were etched in 6.25 N NaOH at a temperature of 70°C in a constant temperature bath for different time intervals but the glass was etched in 5% HF acid at room temperature. Thickness of each sample was measured before and after etching using a digital micrometer (digimatic micrometre, Japan).

Scanning of samples

The sample is scanned each time it is etched and track length is measured using a Carlzeiss binocular microscope at a magnification of 1000X. About 50-60 track lengths and etch pit diameters were taken for each set of observations.

Measurement of the etch rates

The bulk etch rate was determined using the thickness measurement technique. The track etch rate was determined from the slope of a linear part of the curve between track length and etching time for CR-39 and for glass V_T is calculated from the relation given by Fleischer *et al.*[1] :

$$V_T = V_B \frac{1+(D/2V_Bt)^2}{1-(D/2V_Bt)^2} \tag{1}$$

Where D is the diameter of the fission fragment at etching time t. The sensitivity S is defined as the ratio of the track etch to the bulk etch rate (V_T/V_B).

RESULTS AND DISCUSSION

The results for the variation in the bulk etch rate V_B and the sensitivity S, with the IR rays exposure are reported in Table 1. In case of CR-39 both the bulk etch rate and sensitivity increases with the exposure time and approaches a constant value after an exposure of twelve hours. The increase in bulk as well as track etch rates can be explained on the basis of scission of hydrocarbon chains, which enhances the dissolution rate. The chemical effect of infrared radiations is to speed up the rate of reaction in the polymers. The pronounced change in the track etch rate is for the damaged part becomes the center for entrapping more energy[4] thereby increasing the rate of scission. The increase may also be due to the presence of atmospheric oxygen as explained by Heins[5]. Presumably, the energy deposited breaks additional chemical bonds along the tracks and is stabilized by oxidation. The increase of sensitivity is due to the catalyzing effect of infrared radiation.

In case of glass there is a very little variation in sensitivity as well as bulk etch rate during IR exposure. These small changes may be due to excitation and ionization of the surface atoms caused by these radiations. These effects may also occur because electrons are excited sufficiently to leave their normal position and move through the glass network. On comparison it is observed that the IR induced changes in CR-39 track recorder are more pronounced than in glass. Thus the etching correction due to IR exposures must be applied, as the sunlight is associated with high dose (51.7 %) of IR radiations of wavelengths ranging from 0.70 to 3.5 μs[6]. Since glasses are not prone to IR exposure, their use in space studies should be encouraged.

TABLE-1
VARIATION OF BULK ETCH RATE AND SENSITIVITY WITH IR EXPOSURE TIME

IR exposure time (h)	Glass		CR-39	
	V_B (μm/min)	Sensitivity	V_B (μm/hr)	Sensitivity
0	1.15 ± 0.50	2.70 ± 0.63	1.74 ± 0.58	2.40 ± 0.60
2	1.10 ± 0.47	2.69 ± 0.66	2.32 ± 0.61	2.63 ± 0.56
8	1.05 ± 0.49	2.98 ± 0.60	2.71 ± 0.24	4.62 ± 0.31
12	1.00 ± 0.46	2.34 ± 0.57	4.65 ± 0.71	10.32 ± 0.64
24	1.10 ± 0.51	2.34 ± 0.54	5.00 ± 0.66	10.00 ± 0.78

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