FTIR Analysis of UV Irradiated CR-39 Solid State Nuclear Track Detector

Ashok Kumar[1]*, R. K. Jain[2], R.N. Chakraborty [3], Triloki Pandit[4] and B.K. Singh[4]
[1]*Deptartment of Physics, JRE Group of Institutions, Greater Noida-201308 INDIA*
[2]*Deptartment of Physics, ABES-IT Group of Institutions, NH-24 Ghaziabad -201009, INDIA*
[3]*Deptartment of Physics D S College Aligarh - 202001, INDIA*
[4]*High Energy Physics lab, Physics Department Banaras Hindu University Varanasi - 221005, INDIA*
** email: ashokblp@gmail.com*

Introduction

It is well proved that the interaction of electromagnetic radiation with the detector material results in structural changes [1]. These changes depend on several factors such as detector structure, exposure condition, radiation type and energy, irradiation condition, etching process etc. The two major changes observed in solid state nuclear track detectors are chain cross linkage and chain scission. If the probability of cross- linking reaction is larger than chain scission, the material would become hardened. In addition to these changes, small molecules such as CO, CO_2 and H_2 may be produced resulting from bond scission [2].

Fourier Transform Infrared (FTIR) spectroscopy involves analysis of light by measuring the Fourier transformed intensity of a spectrum with the use of a Michelson interferometer or modified version [3].

The effect of UV radiations has been studied by measurement of bulk etch rate, track etch rate and activation energy. In the present study FTIR spectroscopy technique was used to analyze the effects of UV radiations on CR-39 solid state nuclear track detector with and without UV radiation before and after irradiation with Cf - 252 source.

Experimental Details

Nine samples of dimension 1cm x1cm were cut from CR-39 sheet of thickness 0.9 mm, density 1.30 g/cm^3 manufactured by HARZLAS TD-1 (Nagase Landauer Ltd., Japan). The first three samples (first set) were exposed only to alpha radiation with close contact to Cf-252 source. The next three samples (second set) were first exposed to the same alpha source (post exposed) and then treated in air with UV - radiations (alpha + UV). The remaining three samples (third set) (pre-exposed) was irradiated in reverse process (UV +alpha) with the same sources as the second set and under the same conditions (pre-exposed). These CR-39 detectors were irradiated at normal to alpha particles using a weak Cf-252 source of active diameter 6 mm at Physics Department BHU Varanasi India. UV irradiation was carried out with VUV-Monochromator (McPherson 234/302) at High Energy Physics Lab, Physics Department BHU Varanasi India using 30 watt deuterium lamp. The wavelength of monochromator lies in the range 115nm to 370 nm. The present exposure was performed at 160 nm for 30 min. After irradiation and exposure the CR-39 detectors were etched in 6.25N NaOH solution at 70, 80 and 90 ^{o}C temperatures with an accuracy of ±1 ^{o}C for a time period of 4 hrs. The track diameters of alpha particles were measured by using an Olympus microscope fitted with an objective of 100 x (oil immersion). The bulk etch rate (V_B) and track etch rate V_T at 70^{0}C was determined by the track diameter technique [4].

The activation energy associated with bulk and track etch rate at a given temperature were measured using following formula [4]

$V_B = A \exp(-E_B/kT)$ and $V_T = B \exp(-E_T/kT)$.

FTIR analysis was performed using Perkin Elmer Spectrum 65 FT-IR Spectrometer at Physics Department BHU Varanasi India.

Result and Discussion

FTIR spectra of bare CR-39, CR-39 Cf + UV (pre exposed) and CR-39 UV + Cf (post exposed) at 160 nm is shown in Fig.1. From the Figure, it is clear that transmittance increases for the pre exposed sample and decreases for post

exposed sample. Sharp increase is observed in every peak (about 8%) for pre exposed sample and transmittance reduces (about 5%) for post exposed samples.

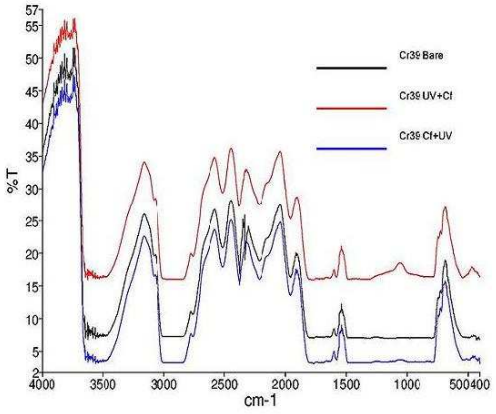

Fig. 1. FTIR spectra of CR-39 bare, CR-39 UV + Cf and CR-39 Cf + UV at 160 nm.

The bulk etch rate, track etch rate and activation energy for bulk etch rate and track etch rate are given in table 1. From this table it is clear that bulk etch rate and track etch rate vary with these three different processes i.e. alpha, alpha+UV, and UV+alpha.

Table 1: Bulk etch rate, Track etch rate and activation energy of CR-39.

Irradiation Type	**Temp °C**	**Bulk Etch Rate (µm/h)**	**Track Etch Rate (µm/h)**	**E_B (eV)**	**E_T (eV)**
Alpha	70	2.9	23.1	0.61 ± 0.52	0.52 ± 0.04
	80	5.5	37.4		
	90	9.1	60.2		
Alpha+ UV	70	3.3	27.5	0.58 ± 0.22	0.58 ± 0.61
	80	5.8	42.1		
	90	9.7	66.5		
UV + Alpha	70	2.7	20.1	0.62 ± 0.47	0.60 ± 0.61
	80	5.1	32.3		
	90	8.5	55.3		

From the table we see that pre and post exposure of UV radiations results significant change in bulk and track etch rates. Activation energy for bulk etch rates for alpha, alpha+UV and UV+alpha irradiated CR-39 are calculated using [4] and found to be (0.61± 0.52) eV, (0.58± 0.22) eV and (0.62± 0.47) eV resp. The activation energy for track etching for alpha, UV+ alpha and alpha + UV irradiated CR-39 is (0.52± 0.04) eV, (0.58± 0.61) eV and (0.60± 0.61) eV resp.

Figure 2 shows the microphotograph of pre exposed CR-39 (UV + Alpha) using an Olympus microscope fitted with an objective of 40 x .

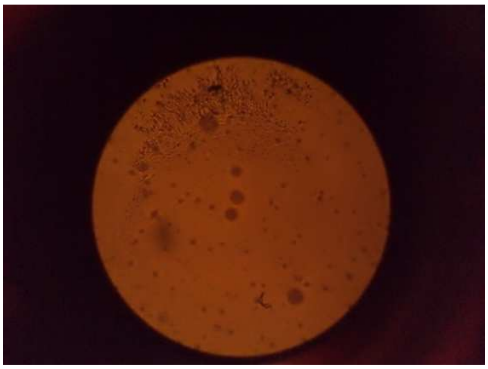

Fig.2. Microphotograph of pre exposed (UV+Alpha) CR-39 detector.

Hence pre-exposure of UV radiations increases the transmittance of the detector and thereby may be used for dosimetry.

Acknowledgement:

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References

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