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EFFECT OF GAMMA RAYS ON PADC DETECTORS

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ABSTRACT

The effect of Gamma radiation in Polyallyldiglycol carbonate (PADC) detectors has been studied in the dose range of 10^0-10^6 Gy. Some of the properties like bulk-etch rate, track- etch rate, activation energy for bulk and track-etching have been found out for different gamma doses from ^{60}Co Source in PADC. The experimental results are presented and discussed.

KEYWORDS

Bulk-etch rate; track-etch rate; PADC; ^{60}Co; ^{252}Cf; gamma dose; activation energy

INTRODUCTION

Polyallyldiglycol carbonate (generally referred as CR-39 in the earlier literature) is a class of plastic detectors which has been used widely for charged particle detection and measurement. It is essential to know the extent to which track registration property of the detector gets influenced by external factors like radiation and temperature. This knowledge leads to useful cautions while using track detectors under varied experimental conditions. It has been reported (Fleischer *et al.*,1975) that irradiation with ultraviolet and high energy photons which do not themselves make tracks can sometimes have profound effects on the properties of track detectors. So far a lot of work has been done on CR-39 (Pershore) (Joseph and Varier, 1995; Shweikani *et al.*, 1993; Sharma *et al.*, 1991; Singh and Singh, 1988 and Portwood and Henshaw, 1986) but no systematic study on the effect of gamma rays (upto 10^6 Gy) on PADC (Homalite) is available. For this reason we have chosen this particular detector.

In the present study, an attempt is made to investigate some characteristics of PADC detector with regard to its possible use as gamma dosimeter. The main objectives have been to study the dependence of bulk-etch rate, track-etch rate, activation energy for bulk and track-etching with different gamma doses.

EXPERIMENTAL PROCEDURE

The PADC detectors (Homalite Corporation, Wilmington, Del. USA) of thickness 0.15 cm and density 1.32 g cm^{-3} were used in this study. Two sets of samples of sizes 2 cm x 2 cm were prepared. One set was first exposed, at normal incidence to fission fragments and alpha particles from a ^{252}Cf source in air for five minutes and then together with the unexposed (second) set, subjected to various doses of gamma rays (10^0 - 10^6 Gy) at room temperature from a ^{60}Co gamma source having a dose rate of 3.0 kGy/h. The second set was subsequently exposed to ^{252}Cf source under the above mentioned conditions. After exposure the detectors were etched in 6N NaOH solution. Etching was carried out at different temperatures, viz., 55°C, 60°C, 65°C and 70°C for different time periods. Each time after etching the samples were thoroughly washed with distilled water and dried. The bulk and track-etch rates (V_G and V_T) were determined from the etched track diameters for both normally incident fission fragments and alpha particles using Leitz optical microscope. The measured track diameters were converted to bulk and track- etch rates by using the standard relations proposed by Shweikani *et al.* (1993).

RESULTS AND DISCUSSIONS

The effect of gamma rays on bulk and track-etch rates for PADC in 6N NaOH at 70°C has been shown in Figs. 1 and 2. By examining these graphs, it is clear that V_G and V_T remain almost invariant upto gamma doses of 10^4 Gy. Then they start increasing slowly till 10^5 Gy. Between 10^5 Gy and 10^6 Gy there is a sharp increase in V_G and V_T, both in pre- and post-gamma exposed samples. It is interesting to see that both the bulk and track-etch rates are higher in the case of post gamma exposure. These results are in good agreement with that of other workers in this field (Sharma *et al.*, 1991; Portwood and Henshaw, 1986 and Khan *et al.*, 1975). A possible explanation for the increase in etch-rates can be attributed to the decrease in the average molecular weight (Fleischer *et al.*, 1965) by scissions of the molecular chains caused by the gamma rays (Khan *et al.*, 1975; Zamani and Charalambous, 1981). On the other hand, in the case of the gamma post-dose, the existing latent tracks produced by the charged particles are enhanced by further scissions along the particle's trajectory by gamma radiation. It is this gamma dose dependence of bulk and track-etch rate of plastic track detectors that can be applied in estimation of the unknown gamma doses of high magnitudes.

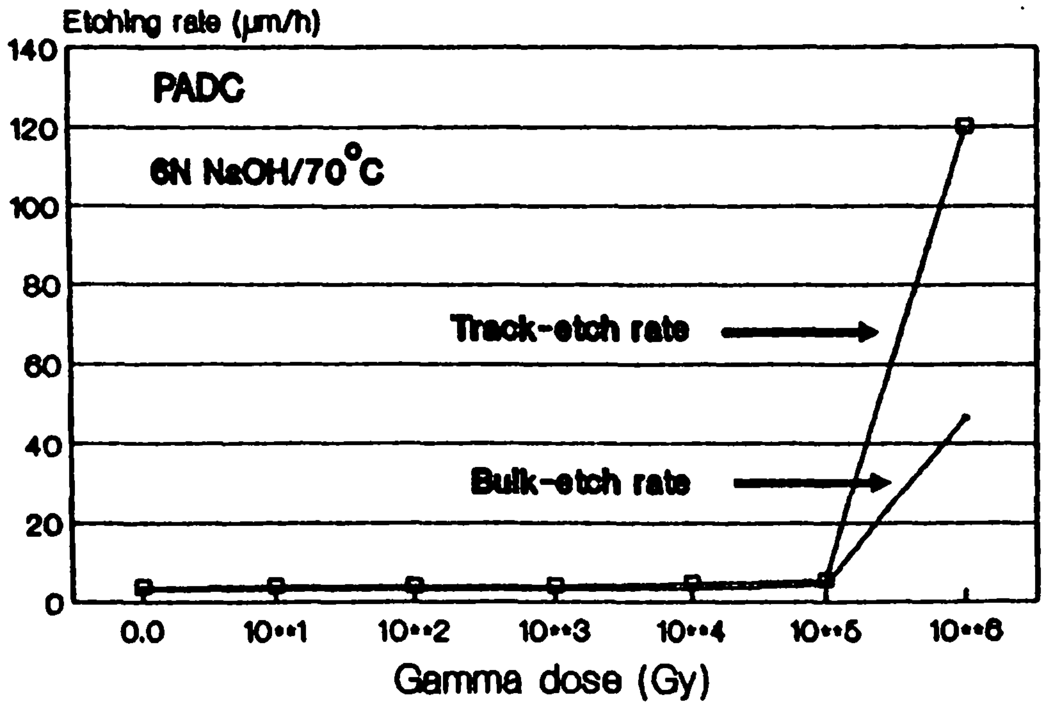

Figure 1. The effect of gamma post-dose on bulk and track-etch rates of PADC.

The activation energy for V_G and V_T have been determined by plotting $\log V_G$ and $\log V_T$ as a function of 1/T at different doses of gamma radiation and are listed in Table 1. It is interesting to observe that activation energies of different doses are almost equal to each other revealing the fact that activation energies are independent of gamma doses.

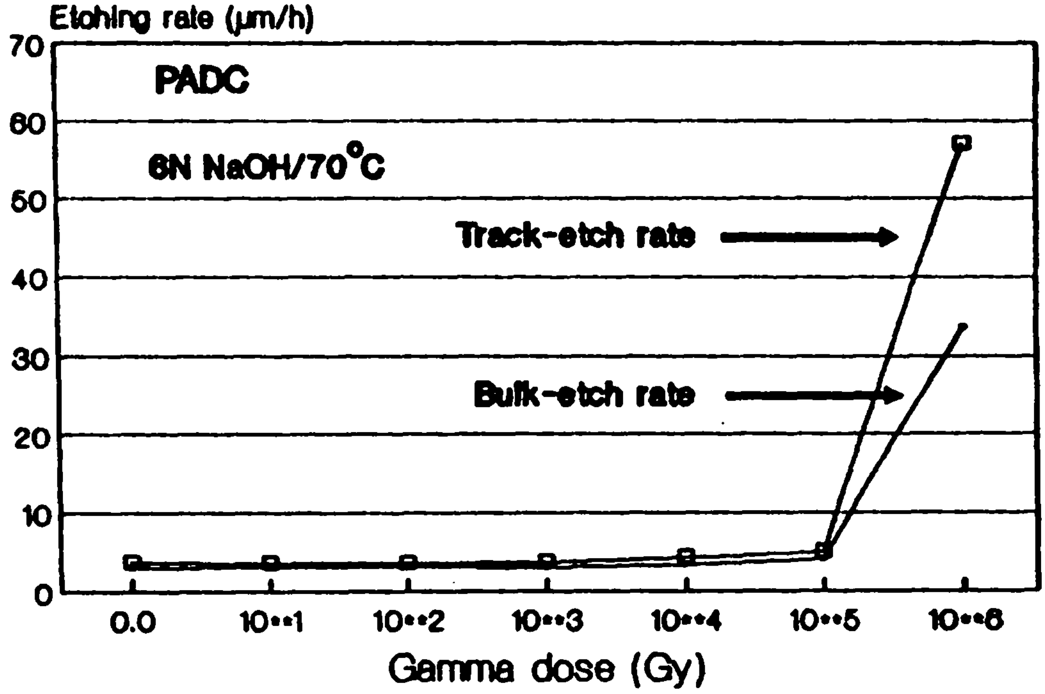

Figure 2. The effect of gamma pre-dose on bulk and track etch rates of PADC

Table 1 : The values of activation energy (in kJ.mol^{-1}) for bulk and track-etching of PADC exposed to different gamma doses.

Etch rate	Activation Energy (kJmol^{-1})						
	No dose	10^1Gy	10^2Gy	10^3Gy	10^4Gy	10^5Gy	10^6Gy
V_G(A)	117.1 ± 4.5	118.7 ± 4.5	119.7 ± 4.5	118.1 ± 4.5	123.9 ± 4.5	117.5 ±7.9	113.6 ± 6.5
V_G(B)	117.1 ± 4.5	117.8 ± 4.5	118.2± 4.5	116.6± 4.5	123.9 ± 4.5	125.2 ± 4.5	121.4 ± 6.9
V_T(A)	111.4 ± 2.3	110.6 ± 2.3	111.3 ± 2.3	110.9 ± 2.3	108.1 ± 2.3	105.9 ± 2.3	107.4 ± 6.8
V_T(B)	111.4 ± 2.3	113.7 ± 2.3	113.9 ± 2.3	110.6 ± 2.3	110.2 ± 2.3	108.5 ± 2.3	108.5 ± 6.4

(A) : Pre-gamma exposure, (B) : Post-gamma exposure.

It was also noted that an increase in the normalized etch rates (the ratio of etch rates with and without gamma exposure) takes place both for bulk-etch rates and track-etch rates. At 70°C, an increase of 15.6 fold for V_G and 33.0 fold for V_T for post-gamma and an increase of 11.3 fold for V_G and 15.1 fold for V_T for pre- gamma have been reflected from the results.

The gamma irradiations in the present work was done at room temperature. It is worthwhile to carry out such studies at low temperatures for better understanding of gamma-ray induced effects on PADC detectors. Further analytical work involving the techniques such as TGA, DSC, IR, ESR, UV and VIS spectroscopy is in progress to characterize the effects of gamma exposure in PADC detectors.

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