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Influence of etching conditions on the efficiency and critical angle of plastic detector Makrofol-N

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The effect of concentration and temperature of the etching agent on Makrofol-N is studied using $^{129}_{54}Xe$ ion beam (7.5 MeV/n) at normal as well as oblique incidence. The critical angle for track revelation in Makrofol-N and the efficiency of track registration is estimated using standard formulation proposed by Somogyi and Hunyadi [*Proc 10th Int Conf on Solid St Nucl Track Detectors, Lyon* (1979) 443].

Polycarbonates have been abundantly studied[1-3] for their application in several areas of nuclear physics and astrophysics. Their relatively high threshold for response to ionization, their remarkable uniformity and consistency combined with good optical transparency after etching makes them most suitable for particle identification[4]. It has been reported[5-7] that the efficiency and critical angle of registration of a solid state nuclear track detector (SSNTD) varies with the concentration and temperature of the etchant. Hence knowledge regarding the optimum conditions for etching is essential, as its improper selection may affect the applicability aspect of any SSNTD.

Makrofol-N with its nonvolatile plasticizer and stable detection sensitivity was chosen in our present study. This widely used plastic has a very low water absorptivity and its response does not depend upon location for large area sheets, as in the case of cellulose nitrate. Here we present in brief, the parameters that affect the efficiency and critical angle for registration of the detector.

In the present workout, Makrofol polycarbonate sheets (thickness = 62 μm and diameter = 2.5 cm) were exposed to $^{129}_{54}Xe$ ions at 7.5 MeV/n energy under vacuum at GSI, Darmstadt, West Germany. The heavy ion fluence of 10^5 ions/cm^2 were injected into the virgin sheets at an angle of 90° and 45°. The circular sheets were cut into small pieces and etched in 4*N*, 5*N* and 6.25*N* NaOH at four different temperatures (45, 50, 55 and 60°C). The scanned oblique data were used to evaluate the track etch rate (V_t) using the standard formulation[4] and V_b (bulk etch rate) was estimated from the diameter of the normal incident tracks. These values of V_b and V_t were used in the formulation of Somogyi and Hunyadi[5]

$$V_t = \alpha_t C^{n_t} e^{-E_t/kT} \quad \ldots (1)$$

$$V_b = \alpha_b C^{n_b} e^{-E_b/kT} \quad \ldots (2)$$

and the various constants involved estimated. These values were then substituted in Eqs (3) and (4) for different conditions of temperature and concentration to tabulate values of efficiency η and critical angle of registration, θ_c (Table 1).

$$\eta = 1 - (\alpha_b/\alpha_t)\, C^{n_b - n_t}\, e^{(E_t - E_b)/kT} \quad \ldots (3)$$

$$\theta_c = \sin^{-1}(\alpha_b/\alpha_t)\, C^{n_b - n_t}\, e^{(E_t - E_b)/kT} \quad \ldots (4)$$

Values of the various constants are: $E_b = 0.689$ eV; $E_t = 1.28$ eV; $n_t = 1.40$ and $n_b = 0.91$.

Table 1—Values of η and θ_c at different temperatures and concentrations

Parameter	Concentration	Temperature, °C 45	50	55	60
η	4*N*	0.9991	0.9995	0.9995	0.9997
θ_c		0.0046	0.023	0.0204	0.0132
η	5*N*	0.9991	0.9994	0.9996	0.9996
θ_c		0.048	0.0292	0.0210	0.0187
η	6.25*N*	0.9992	0.9991	0.9995	0.997
θ_c		0.044	0.046	0.031	0.0169

The variation of θ_c and η with temperature and concentration are studied. It must be noted that our present results are partly consistent with those obtained by Somogyi and Hunyadi[5] for CR-39, θ_c decrease with an increase of temperature for a particular concentration is a finding, contrary to those reported by Somogyi and Hunyadi[5] and Modgil and Virk[8], whereas its variation with etchant concentration at a particular temperature follows the general trend. The present work indicates that efficiency is independent of temperature and concentration; the results of Somogyi and Hunyadi[5] support our findings.

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