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THE EFFECT OF STIRRING AND INTERRUPTION ON THE ETCHING CHARACTERISTIC OF CR-39 TRACK DETECTOR

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Abstract

Etching behavior of the CR-39 plastic track detector hve been studied. From bulk etch rate as well as from track etch rate, the sensitive equilibrium of this detector in NaOH solutions is examined in detail. A comparison of discrimination properties between NaOH and KOH is made .

Keywords: CR-39 ; Alpha Particles ; Normality ; physical parameters;Comparison

1. *INTRODUCTION*

Ionizing particles passing through polymeric track detectors produce latent tracks that are trials of radiation damage[1] Tracks of ionizing particles can be easily developed by means of a suitable selective chemical etch in dielectric track detector. The type of plastic detectors are the CR-39 films. These films are of polycarbonates be which must be specially treated to enhance its response to ionizing particles having a sufficiently high energy loss (or some other characteristic of the particle related to the energy deposition along its trajectory)[2].

To achieve the highest charge and isotopic resolution in the measurements using plastic detectors it is necessary to know the optimal etching conditions. The characteristics of the observed tracks are affected by etching conditions, especially the properties of registration[3] . Several studies have been made on the behavior of plastic detectors to various etching conditions[4-7].The results obtained depend on etching technique, the chemical etching being the most frequently used. The behavior of the CR-39 material can be studied by measuring the characteristics of tracks revealed usually in an alkaline bath.Here the basic problem appeared to be the colloid layer adhered to the surface of the samples.This layer consists of the etching products, mainly the camphor, is of low solubility in the etchant [4,8,9]. Thus the etching process is influenced by various parameters,i.e. the stirring of the solution during etching. Also as the colloid layer is soluble in water the process of interruptions (followed by prolonged washing in water) gives better results.The influence of all the above parameters to the etching behavior of CR-39 plastic detector was examined in detail and is presented below.

2- EXPERIMENTAL

The pieces of CR-39 detectors, each having 1cm × 1 cm size, were used in the present investigations. All the samples were etched in 200 ml of(2,4,6,8,10) N NaOH and KOH solutions at(45,55,65,70,and 75) temperatures for 3hr(chemical etching). After each normality concentration for different temperatures of solutions, in detectors the following physical quantities: bulk etch rate and track etch rate of the etchant were modified and in this paper the rates of modification are determined. as also placed in the same etching bath and the values of its bulk etch rate and track etch rate were also measured after each normality interval for different temperatures of water bath. The ratio of track etch rate to bulk etch rate as a function of the concentration of NaOH and KOH were measured . The diameters of tracks alpha particles were measured by using the Optical Microscope for the CR-39 detectors.

3-ETCHING BEHAVIOUR OF CR-39 DETECTOR

In order to determine bulk etching velocities, V_g, the evolution of ^{241}Am was supplied by the Radio Chemical L.t.d Amersham, England , it is fission fragments radii with etching time was used. The Irradiations were made normally to the sheet surface using collimator in a vacuum chamber. The behavior of bulk etching rate for various concentration of KOH and NaOH solutions was studied. For both cases etching was made for various temperatures. Typical results for bulk etching rate are given in Figs 1 (a) and (b). The presented results were obtained with interruptions during the etching process.

For the case of KOH solutions [Fig. 1(a)] the linear increasing dependence of bulk etching rate is related to the increasing activity of the solutions. It should be noticed that no saturation was observed for high concentrations. For NaOH solutions, however, bulk etching rate does not follow a monotonous law [Fig. 1(b). For low concentrations we have an increasing etching velocity. The same behavior is shown for high concentrations, above 8N. This part of the curve does not correspond to the extrapolated part of low concentrations and evidently is correlated to the deepening appeared in the region of 4-7N. The whole behaviour of the bulk etching rate of CR-39 in NaOH solutions shows a dependence on the concentration of the solutions. As it is known from other detectors of the same composition, stirring and interruptions play an important role in the etching process[3]. The influence of these parameters on etched CR-39 with NaOH solutions is presented in Fig. 2. Curve (a) corresponds to continuous etching of 3 h duration. Curve (b) gives the results for etching with the stirring of the etchant. Finally curve (c) is obtained without stirring using interruptions. In each interruption the samples were washed in distilled water for a long washing time, of the order of 25 min. Interruptions were made after 35, 60 and 85 min etching of time. It is important to notice here that a remarkable influence of stirring and interruptions is not observed to the bulk etching behavior (Fig.2), contrary to our knowledge on the other plastic materials. It is known that the variations on etching velocity are correlated with the removed etching products from the surface of the samples. The peculiar equilibrium found for NaOH solutions is related to the lower solubility of etching products in NaOH solutions than in potassium solutions[9]. The results shown in Fig. 2,e.g. independent of stirring and interruption , for the case of NaOH lead to the conclusion that the etching products are of low solubility also in water.

Track etching rates were studied for alphas in the same samples used for bulk etching determination. We used alphas of 5.48 MeV from ^{241}Am. The track etching rate was determined from[10]:

$$V_t / V_g = (r^2_f + r^2_a) / (r^2_f - r^2_a) \quad \ldots\ldots (1)$$

Where r_f is the fission fragment radius and r_a the radius of alphas. Equation (1) is only valid for V_t= const. and V_g= const. The radii are measured in the same etching time, r_f being the removed thickness h :

$$V_g t = h = r_f \ .$$

The behaviour of the ratio V_t / V_g for various concentrations is shown in Fig. 3, for the two etchant used , curve(a) for KOH and (b) for NaOH at 70°C. The values correspond to the appeared alphas of 5.48 MeV of ^{241}Am(initial phases of development). For the KOH solutions the behavior of the ratio is similar to that of the other plastic materials [4]. It is concluded that the preferential etching condition corresponds to the region of 6-8 N. Here the ratio V_t / V_g is sufficiently high for initial phases of development and reflects the best conditions of particles registration. For NaOH solutions the ratio is saturated above 6 N. In the case of the ratio of the two velocities we also have the problem of the diffusion of etch products out of the wells. Thus it is evident that etching in NaOH solutions above 5 N gives the same results as with higher concentrations. It is also observed that the optical contrast of the tracks is better in low temperatures, e.g. 30-60°C. This effect is related to the decreasing V_g , which results to increasing ratio V_t / V_g and to longer visible tracks, for prolonged etching times.

CONCLUSIONS

(a) The behavior of CR-39 plastic track detector in KOH solutions follows the activity of the solutions. For the case of NaOH solutions the non monotonous behavior of bulk etching rate is indicative of an unstable state. So it is preferable to use NaOH solutions below 4 N, since we have the same bulk velocities as those for higher concentrations [see Fig. 1(b)].

(b) As deduced from track etching rate the preferable etching condition for CR-39 is the region of 6-8 N of KOH solutions in relatively low temperatures.

(c) Etching behavior is slightly dependent on stirring during etching. Also the interruption gives unaffected results on etching process.

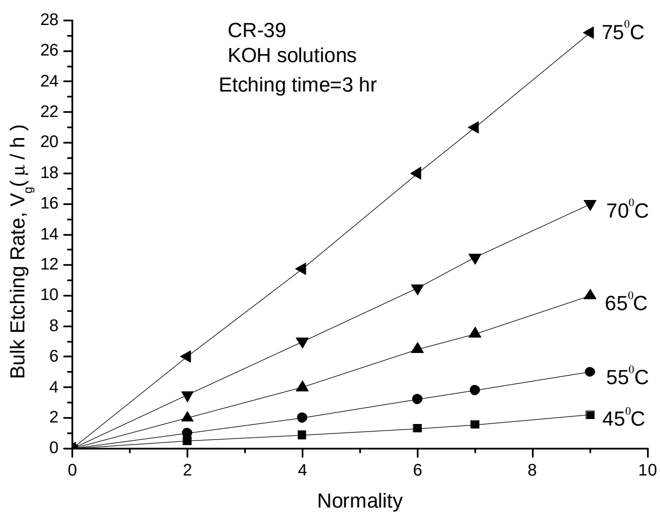

FIG. 1(a). Bulk etching rate as a function of the concentration of KOH solutions. The parameter of the curves is the temperature of the solutions.

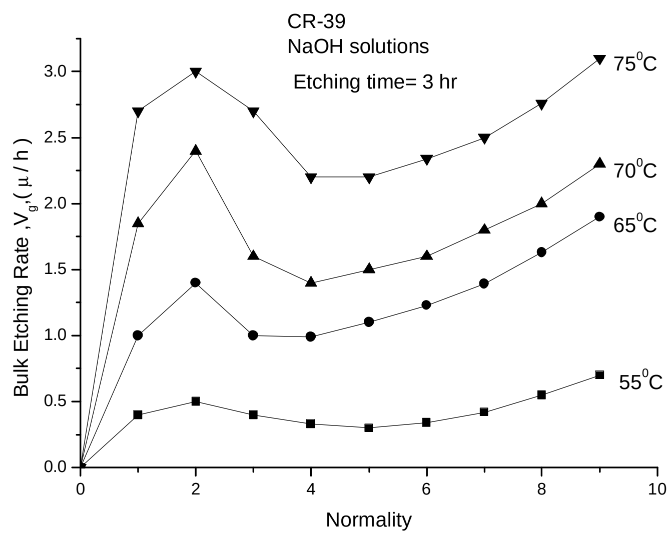

FIG. 1(b). Bulk etching rates as a function of the concentration of NaOH solutions. The parameter of the curves is the temperature of the solutions.

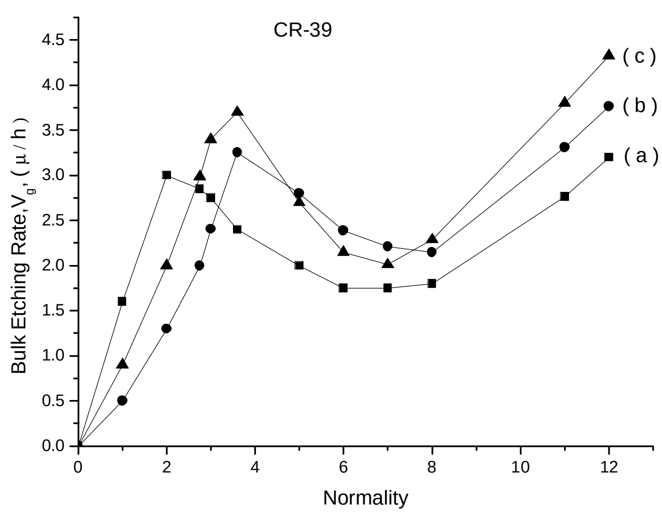

FIG. 2. Examination of some etching parameters on the etching behavior of CR-39 detector. (a) Continuous etching ; (b) etching with stirring ; (c) etching with interruptions.

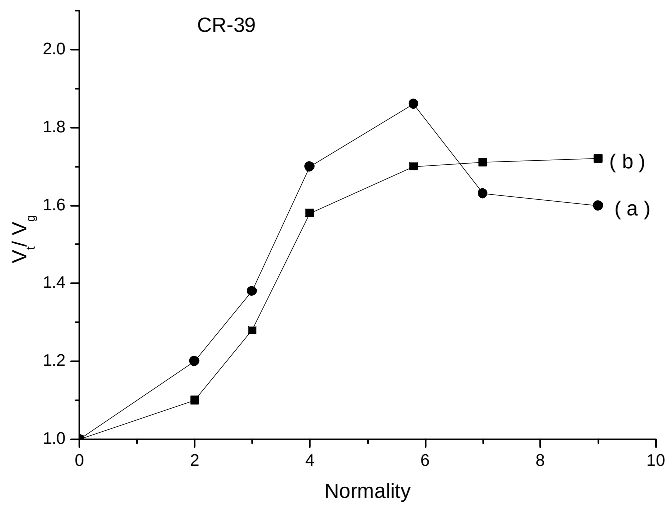

FIG. 3. Track etching rate for various concentrations of KOH (curve a) and NaOH (curve b) solutions. The curves correspond to the initial phases of development of alphas from ^{241}Am source.

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دراسة تأثير الاثارة والتوقف على مميزات القشط لكاشف الاثر النووي CR-39

المستخلص

لقد تم دراسة سلوك القشط الكيمياوي لكشف الاثر النووي CR-39 باستخدام محلول القشط NaOH و KOH مع تشخيص الحساسية المتوازنة للكشف باستخدام نفس المحلولين من معرفة معدل الحفر العام V_B و معدل حفر الاثر V_T, كما تمت المقارنة بين المميزات التي حصلت للكاشف باستخدام محلولي القشط NaOH و KOH.