

Evaluation of Bulk Etch Rate of Solid State Nuclear Track Detector CR-39

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Abstract. In the current study, the bulk etch rate V_B of solid state nuclear track detectors SSNTDs CR-39 have been examined at different concentrations of NaOH solution ranged from 4N to 8N and different temperatures of NaOH solution (50, 60, 70, 80 °C) for various time intervals of etching (1-10 h); this is done by determination of mass variation via etching time. The results indicate that the bulk etch rate V_B increases with the increase of etchant solution concentration and the temperature of solution. This can be attributed to the increase the thickness of the removed layers h of the detector.

Introduction

The solid state nuclear track detectors SSNTDs are insulating materials have been usefully employed in a number of different fields of science and technology [1-3].

The solid state nuclear track detectors are formed in a variety of materials which is fall into two main categories: inorganic solids such as crystals and glasses, and organic solids such as polymers. These types differ in their sensitivity which increases with increasing of incident particle atomic number.

One of the basic parameters required for the use of the SSNTDs is the bulk etch rate V_B [4]. The bulk etch rate V_B is the rate of chemical etching of the undamaged surface. It is defined as the thickness that is etched out from one of the surfaces of the detector as per time as a result of chemical etching effect [5]. It depends on the construction of the plastic, the constituents of the etching solution, its concentration and temperature [6].

The value of V_B is required to be known, for example, for determining the other important parameters like track etch rate V_T and the track revelation efficiency η . These parameters are required for certain practical applications of SSNTDs. Therefore, it is important to critically assess the methods of measuring V_B [7].

There are different methods of determining bulk etch rate V_B for SSNTDs, one is the measurement of mass of the removed surface, Δm , during the etching process of a detector surface in a specific interval of time Δt [7].

The effect of the concentration and temperature of the etching solution during the etching process have been studied using mass-measurement to determine the bulk etch rate V_B for SSNTDs CR-39.

Experimental Details

The bulk etch rate V_B is one of the most important parameters that control the formation and development of tracks; it is important to know that V_B depends on many factors such as the chemical composition and preparation of the detector, the type of etching solution and the etching conditions (temperature and concentration of etching solution) [8].

The bulk etch rate V_B was determined by weighted the mass of detectors during etchant process. Thus, if the area of the detector A , and the density of the detector ρ , and removed mass of the detector Δm , which use to find thickness of the removed layers h during the etching process in a specific interval of time Δt , so it will be [7]:

$$\Delta h = \Delta m / 2A\rho \quad (1)$$

$$\Delta h = V_B \cdot \Delta t \quad (2)$$

$$V_B = 1 / 2A\rho \times \Delta m / \Delta t = 1 / 2A\rho \times | \text{slope of } m(t) | \quad (3)$$

Where $\Delta m = m_1 - m_2$; m_1 : is the initial mass before etching; m_2 : is the final mass after etching. $\Delta m / \Delta t$ represents the slope of the relation between the mass of the detector and the etching time.

A total of 20 pieces of CR-39 track detectors (type pershore, UK, density = 1.32 g/cm³) each having dimension of (1 × 1 × 0.05) cm³ was etched with different concentrations of NaOH solution (4, 5, 6, 7, 8 N) respectively, at different temperatures of solution (50, 60, 70, 80 °C) for different time intervals of etchant process duration (1-10 h).

The mass of detectors was weighted using electronic sensitive balance having an accuracy of 0.0001mg. Each measurement was recorded for at least five times. The bulk etch rate of CR-39 has been calculated using Eq. (3).

Results and discussion

In order to observe the effect of concentration of NaOH solution, temperature of etching solution and etching time on the removal mass and the bulk etch rate of CR-39 detectors, the detectors have been etched with different concentration of NaOH solution for different temperatures in specific durations .

The results for the removal mass and bulk etch rate for CR-39 are graphically displayed in figures (1, 2).

Fig. 1 shows the mass of the detector as a function of etching time for different temperatures of etching solution with different concentration of NaOH.

From fig.1, the mass of the detector has decreased with increase of etching time, concentrations of NaOH and temperatures of etching solution. This indicates significant removal of mass caused in the plastic by etchant concentration because of the increase of thickness of the removed layers h of the detector.

The behavior of the decreasing mass with the etching time corresponds to that showed in the research [7].

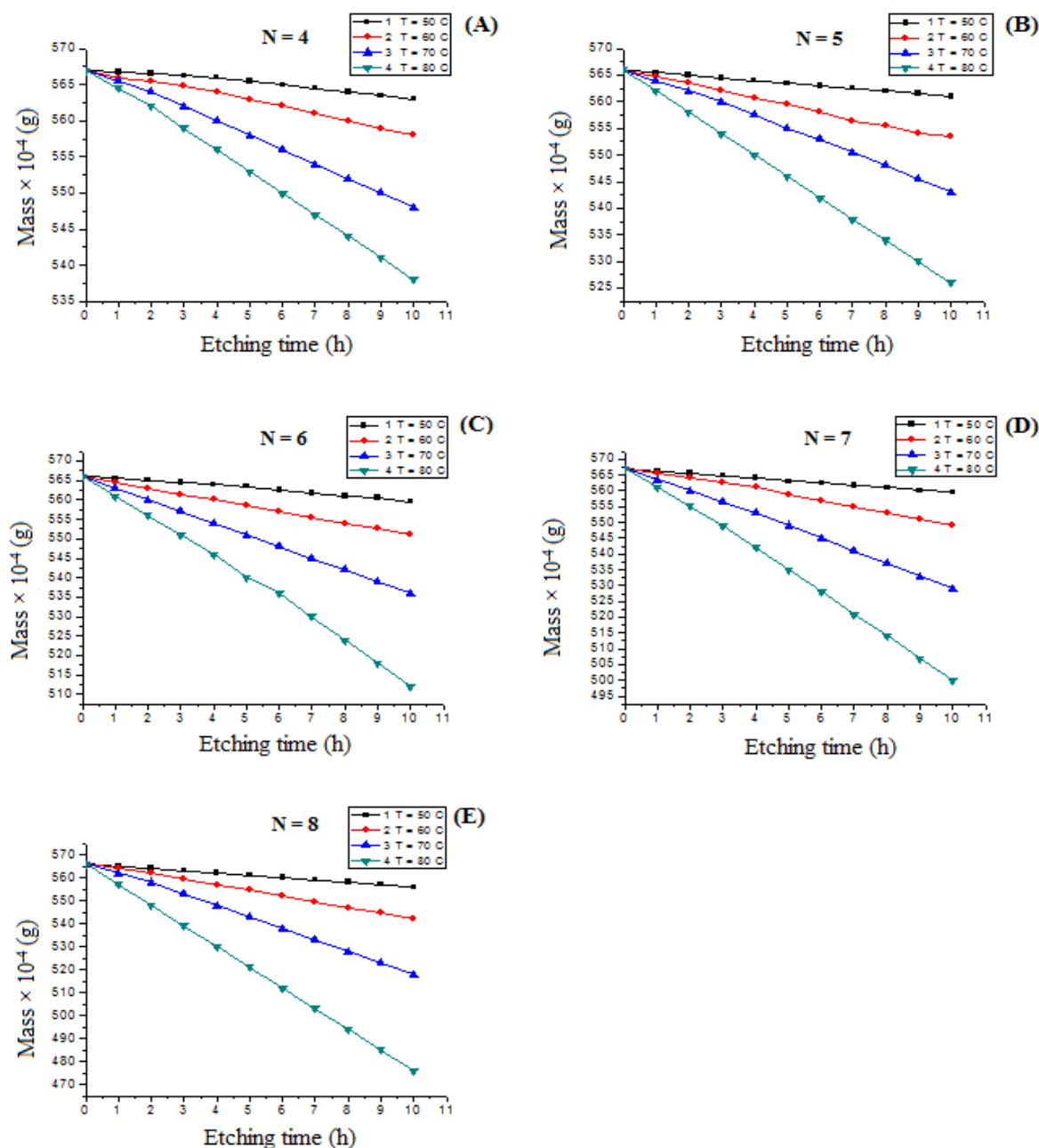


Fig. 1 Mass of detector as a function of etching time for different temperatures of etching solution with different concentrations of NaOH: (A) 4N, (B) 5N, (C) 6N, (D) 7N and (E) 8N.

Fig. 2, represents the relation between bulk etch rate V_B and normality of etching solution for different temperatures of solution. From this figure, the bulk etch rate has increased with increasing of both the concentrations and temperature of etching solution.

The concentration of the etchant increases when the same etchant solution is used for longer duration due to the evaporation of water; this leads to decrease the mass of detector and, thus, increase the bulk etch rate.

The behavior of increasing bulk etch rate with the increase of etching concentration agrees with the results of other researchers [7- 9].

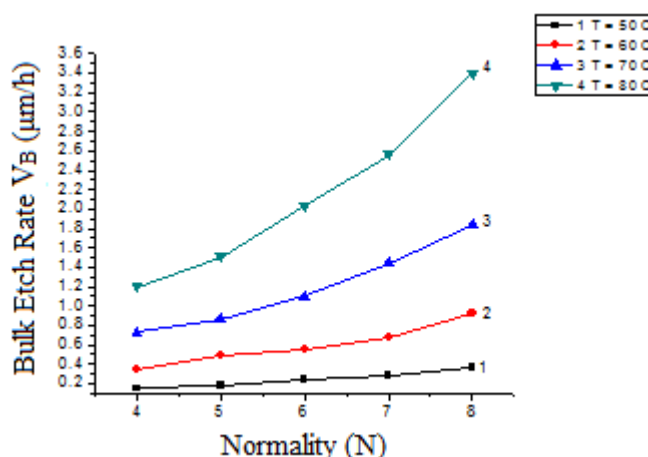


Fig. 2 The relation between bulk etch rate and normality of NaOH for different temperatures of etching solutions.

Summary

From the abovementioned results, it is found that there are increases in both the bulk etch rate V_B and removed mass of the detector with the increase etchant solution concentration, etching time and etchant solution temperature.

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