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Effect of Gamma Rays on The Bulk Etching Rate of LR-115 Detector

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Abstract: *It is important to measure the bulk-etching rate for any solid state nuclear track detectors, because they have an application in different fields of sciences. The effect of gamma rays emitted from ^{60}Co source with different doses on LR-115 detector was studied. The bulk etching rate of the detectors was measured before and after irradiation using gamma source. From the results the values of the bulk etching rate of LR-115 without gamma rays have been 3.10 μmh^{-1} and that under gamma irradiation with different doses were ranged from 4.60 to 8.77 μmh^{-1}. This means that the values of the bulk etch rate increase with increasing gamma doses.*
Keywords: *LR-115detector, Bulk etching, Gamma, Dose.*

I. Introduction

Nuclear track detectors (NTDs) used as a detecting device in various fields and used as a passive system to detect alpha contamination[1]. SSNTDs are also known as etched track detectors, and have been extensively used for the registration of charged particles. There is much kind of detectors, like CR-39 and LR-115 type II detectors [2-3]. SSNTDs material is light weight, small volume, electronics free, easy to process and very cheap comparing to any active detectors. These detectors are used to measure the radon concentration in the environmental samples [4-5]. LR-115 type II is a cellulose nitrate ($C_6H_8O_9N_2$) material, which used to detect alpha particles. LR-115 detector consists of an active layer with thickness 12µm of cellulose nitrate on clear polyester (100µm) base substrate. LR-115 detector is based on cellulose nitrate and used as a detector in radiobiological experiments [6-7]. The etching process is important to the formation of visible tracks which formed on the detector. The bulk etch rate is the removing rate of the undamaged surface of the detector by chemical reaction between the surface of detector material and etching solution, which due to removal of material from the detector surface. During etching, the material of detector is removed layer by layer and the detector thickness becomes smaller and smaller [8]. When a heavily ionizing charged particle passes through such materials, it leaves a narrow trail of damage of a few angstroms in diameter along its path [9]. The bulk etch rate (V_B) is the fundamental interest for understanding the track formation process in solid state nuclear track detectors [10].

Irradiation of the polymers using gamma ray, generally leads to a radiation damage, which modifies the properties of the detector surface [11]. If an ionizing radiation passes through a polymer, the incident energy is transferred to the medium as a result of primary ionization and excitation of the target molecules. These ionization and excitation processes inside the target lead to break of the original bonds. Irradiation is an established tool for modifying the properties of polymers and has attracted growing attraction for potential technological application due to the increased use of these materials [12-13]. The work aimed to study the effect of gamma rays on the bulk etch rate of LR-115 detector. This is an important to determine the equivalent dose in the field of gamma dosimetry, which used as radiological protection, monitoring, radiology and nuclear medicine measurements. Also the detector has been employed for radon measurements by many investigators.

II. Materials And Methods

In the present work the bulk etching rate was determined by using the mass change method. A pieces of LR-115 type II (manufactured by Kodak Pathe' France) detectors were irradiated using ^{60}Co gamma cell was used as a gamma source with applied doses of (10, 20, 40, 80, 100) kGy. The irradiation process was performed at room temperature at National Centre for Radiation Research and Technology, Atomic Energy Authority, Cairo, Egypt. The detectors were divided into five groups, each group consists of five detectors and each detector has an area (1.5 x 1.5) cm^2. The first group was irradiated with 10 kGy of ^{6o}Co gamma rays. The second group was irradiated with 20 kGy gamma radiations. The third, fourth and fifth groups were irradiated with 40 kGy, 80 kGy and 100 kGy respectively. Another group of LR-115 consists of five detectors was used to determine the value of the bulk etch rate without exposed to gamma radiation. All groups of detectors were etched in 10 % of sodium hydroxide solution at 60 ± 1°C in a water bath for (15, 30, 45, 60 ,75) minute. The detectors were weighted carefully using a digital balance of accuracy 0.0001gm before and after chemical etching. After etching all pieces of detectors were washed in running water for 10 minutes with agitation in order to remove all products from the surfaces. After wash time do a final rinse in distilled water and ethyl alcohol solution (1:1) during 2 minutes at 20°C and dried in air [14]. The bulk etching rate was determined using the following equation:

$$V_B = \frac{\Delta m}{2\rho A t}$$

Where, Δm is the difference between the mass before and after etching, A is the surface area of the detector, t is the etching time and ρ is the density of the detector material 1.52 gcm^{-3} [15-16].

III. Results And Discussion

The bulk etching rate without gamma rays has been found to be 3.10 μmh^{-1} and that under gamma irradiation with different doses (10, 20, 40, 80, 100) kGy were found to be 4.60, 5.95, 6.85, 9.60 and 8.77 μmh^{-1}, respectively. **Fig.1** gives the relation between etching time and mass change without exposure to gamma rays. The figure indicates that the values of mass increase with increase etching time at a constant temperature and concentration of etching solution. **Fig.2,** shows the relation between the etching time and the values of mass change at exposure for different gamma doses.The figure appears that the change of mass is high at after exposed to doses of 40 to100 kGy and the change of mass after exposed to 10 and 20 kGy is nearly equal.

Fig.3, gives the relation between the different gamma doses and bulk etch rate of LR-115. The correlation coefficient of the relation is equal≈ 0.88 this means that the relation is acceptable. This indicates that the values of bulk etching rate increase with increase gamma dose exposure, this due to suggests a way to shorten the required etching time, which will be very useful if a large amount of detectors have to be measured within a short time,e.g.,during a large-scale survey. The increasing in bulk etch rate mean that gamma ray interaction with the material of detector and causes destroy in the structure of the bonds of the polymer. The characteristics of the polycarbonate plastic detector are affected when exposed to high dose of gamma-rays. When ionizing radiation passes through a polymer, the incident energy is transferred to the medium due to make primary ionization and excitation of the polymer molecules.

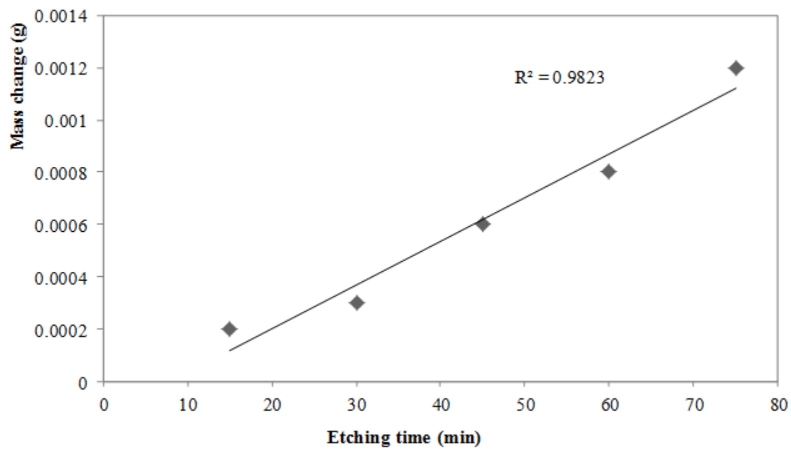

Figure1. The relation between etching time and mass change of LR-115 detector without exposure for gamma rays.

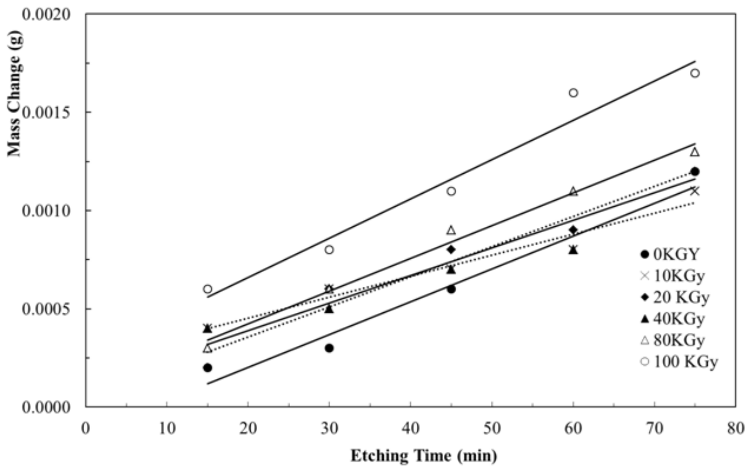

Figure 2. The relation between etching time and mass change of LR-115 detector at different gamma doses.

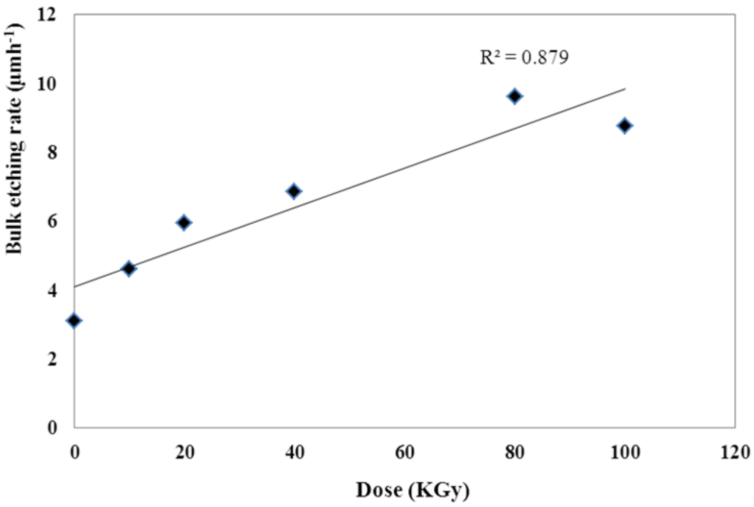

Figure 3. The relation between dose and bulk etching rate of LR-115 detector

IV. Conclusion

LR-115 detector used as detecting devices and as a passive system to detect alpha contamination in the environment, so that the bulk etch rate of detector must be known. From the obtained results the values of bulk etching rate increasing with increasing gamma doses. The change in bulk etching rate at exposed to different gamma doses comes from destroy in the structure of the detector. The effect of gamma irradiation is highly pronounced on the detector surface, from this we can use gamma irradiation to shorten track formation time of this detector by knowing exposure energy and it helpful to study the change of properties of the detectors due to exposed for gamma rays.

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