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Image Analysis of Cr-39 and Cn-85 Detector Irradiated by Thermal Neutron

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Abstract- Image processing technique used Image-J program to analysis tracks of α - particles in the nuclear track detectors type CR-39 and CN-85 after irradiated detectors by thermal neutrons from (^{241}Am-^{9}Be) source with activity 12Ci and neutron flux 10^5 n.cm^{-2}.s^{-1}. Alpha particle incident on detector produce from $^{10}B(n,\alpha)^7Li$ interaction after covered the detectors within boric acid H_3Bo_3 pellets. The irradiation times T_D from thermal neutron source for both detectors were 4h, 8h, 16h and 24h. The analyze of outputs Image-J program for irradiated detectors found the irradiation time T_D has behavior linear relationships with maximum track number M_{RA} (with depended on track area A_T) at range of radiation response region 12 µm^2- 22 µm^{2}for CR-39 detector and 5 µm^2 - 27µm^{2}for CN-85 detector. Also the behaviorofirradiation time T_D with maximum track number M_A (without depending on track area A_T) was linear relationship. The behaviors of maximum track number M_{RA} and maximum track number M_A with irradiation time T_D which calculated by the Image-J program may be reflect to thermal neutron effect on CR-39 and CN-85 detectors.

Keywords- Image processing, Solid-state detectors, Neutron radiation effects, Image analysis.

I. INTRODUCTION

Solid-state nuclear track detectors-SSNTDs have found a large field of applications in various domains of science such as nuclear physics, geochemistry or geochronology [1]. There were many techniques used with tracks in SSNTDs include application of Fourier optics and also applying image processing techniques to improve track images [2]. In fact, these methods are able to improve applications of SSNTDs, particularly when they are accompanied by image processing techniques [3]. In 1976 W. Abmayr *et al.* used an on-line TV-system for real time analysis of two-dimensional images is described which is being used for automatic evaluation of track detectors [4]. Then James H. and Adams Jr.measured of tracks made by Alpha particles and fission fragments in CR-39nuclear track detectors automatically by image analysis software using an accurate programming processor [5], R. Flores et. al. used device efficient in track counting for SSNTD which consists of an optical Fourier processor [6].When an automatic counting method with an image scanner used by H. Ohiwa and N. Wada [7], through using a code for the numerical analysis of images from a CCD camera has been written and applied to the visualization of α-particle tracks in the solid state nuclear track detectors [8] . Computer program named TRIAC I and TRIAC II written in MATLAB has been developed for track recognition and track parameters measurements from images of the solid state nuclear track detectors CR39 by D.L. Patiris *et al.* [9-10].

Used Image J program was used in many of the studies which tested in semi-automated mode for a computer-assisted alpha track counting of electro-chemically etched [11], while used software with fluorescent nuclear track detectors - FNTDs and plastic nuclear track detectors(PNTDs) to evaluate the contested accuracy of CR-39 [12,13] there for used Image J software to analysis fluorescent nuclear track detectors - FNTDs irradiated heavy charged particles [14], also used in fission track analysis of electrodeposited uranium alpha sources [15].

II. MATERIAL AND METHODS

The solid state nuclear track detectors were CR-39 and CN-85 manufactured by TASTRAK Pershore Moulding ,Track Analysis System Ltd. , UK, and Kodak-Pathe, France respectively. Both detector in the form of sheets with thickness 1 mm and 0.1 mm. for CR-39 and CN-85 respectively. CR-39 and CN-85 detectors cut into eight small pieces, four pieces for each detector with dimensions 1cm × 1cm.After that prepared eight samples of boric acid powder (H_3Bo_3) , each boric acid sample has weight 0.5 g. pressed by piston for 30s under 150 par of the force in steel piston with thickness 1mm and diameter 2cm. The pelletscovered with CR-39 and CN-85 detectorsand put a pellets and detectors around the paraffin wax and irradiation samples with thermal neutron at distance of 5cm from neutron source (^{241}Am-^{9}Be) with activity 12Ci and flounce of thermal neutron 10^5 n.cm^{-2}.s^{-1} The irradiation times - T_D were 4h , 8h , 16h and 24h for CR-39 and CN-85 detector which covered by boric acid H_3Bo_3 pellets.

After thermal neutron irradiation remove boric acid pellets from CR-39 and CN-85 detectors. The chemical etching solution was sodium hydroxide NaOH solution with 6.25N for CR-39 at temperature 60°for etching time 30 min while for CN-85 normality was 2.5N at 50° temperature in 15 min of etching time. Image processing used byImage J program which is written in Java language and take images for detectors which contain on the nuclear tracks and store these images (pixel unit) in computer at the form(jpg . file) . One pixel in these image was equal to converting factor 0.4225 μm which calculated experimentally by using of role scale in optical microscope.

III. RESULTS AND DISCUSSION

The first step in this program was opened the image which will process and convert this image into binary system as show in figure 1. The output analysis processing after convert to binary system which give us relations between track parameters, figure 2 show the relation between the track number - N with track area (μm^2) for different irradiation time-T_D for two type of detectors CR-93 and CN-85. From this figure obtained increase in the value of maximum track number - M_{RA} (relative to track area) with increase in irradiation time - T_D.

From this figure 2, the maximum values of track number relative to area of track M_{RA} 6 , 20 , 32 and 44 track for irradiation time - T_D 4h , 8h , 16h and 24h respectively inCR-39 detector . While in CN-85 detectorthe value of M_{RA} were 9, 16, 25 and 32 for irradiation time - T_D 4h, 8h, 16h and 24h respectively. That maximum value of M_{RA} for CR-39 and CN-85 detectors has linear relationship with irradiation time -T_D as show in figure 3.

The linearrelationships between irradiation time - T_D and maximum track number - M_{RA} (relative to track area)which obtained from figure (3) for CR-39 and CN-85 detectors was obtained in equation(1) and (2) respectively

$$T_D\ (h) = 0.54\ M_{RA} - 0.66 \quad (1)$$
$$T_D\ (h) = 0.87\ M_{RA} - 4.88 \quad (2)$$

While can found relationship from figure 2 between irradiation time - $T_D$and maximum track number - M_A (without depending on track area) for each curve of irradiation time - T_D 4h , 8h , 16h and 24h as show in figure 4 .

That relations was behavior as linear relationshipwhich reflect the increasing of irradiation time - T_D with increase maximum track number - M_A in figure 4which calculated these relations by equation (3) and (4) for CR-39 and CN-85 respectively.

$$T_D\ (h) = 0.68\ M_A - 5.97 \quad (3)$$
$$T_D\ (h) = 0.87\ M_A - 4.88 \quad (4)$$

IV. CONCLUSION

From this study show there are possible to using Image-J program to image analysis for the nuclear track . The radiation track for the thermal neutrons in terms of irradiation time - $T_D$was determined after find the value of maximum track number M_{RA} and with maximum track number M_A. The image analysis for nuclear track detectors NTDs image processing can be use another programs more development from Image-J program.

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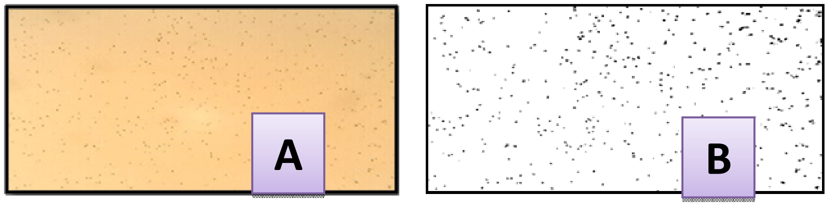

Fig.1. A) First step from image processing of Image-J program which obtained the track image in detectors after radiation.
B) Second step from image processing of Image-J program which obtained the convert to binary system in image of detector after first step.

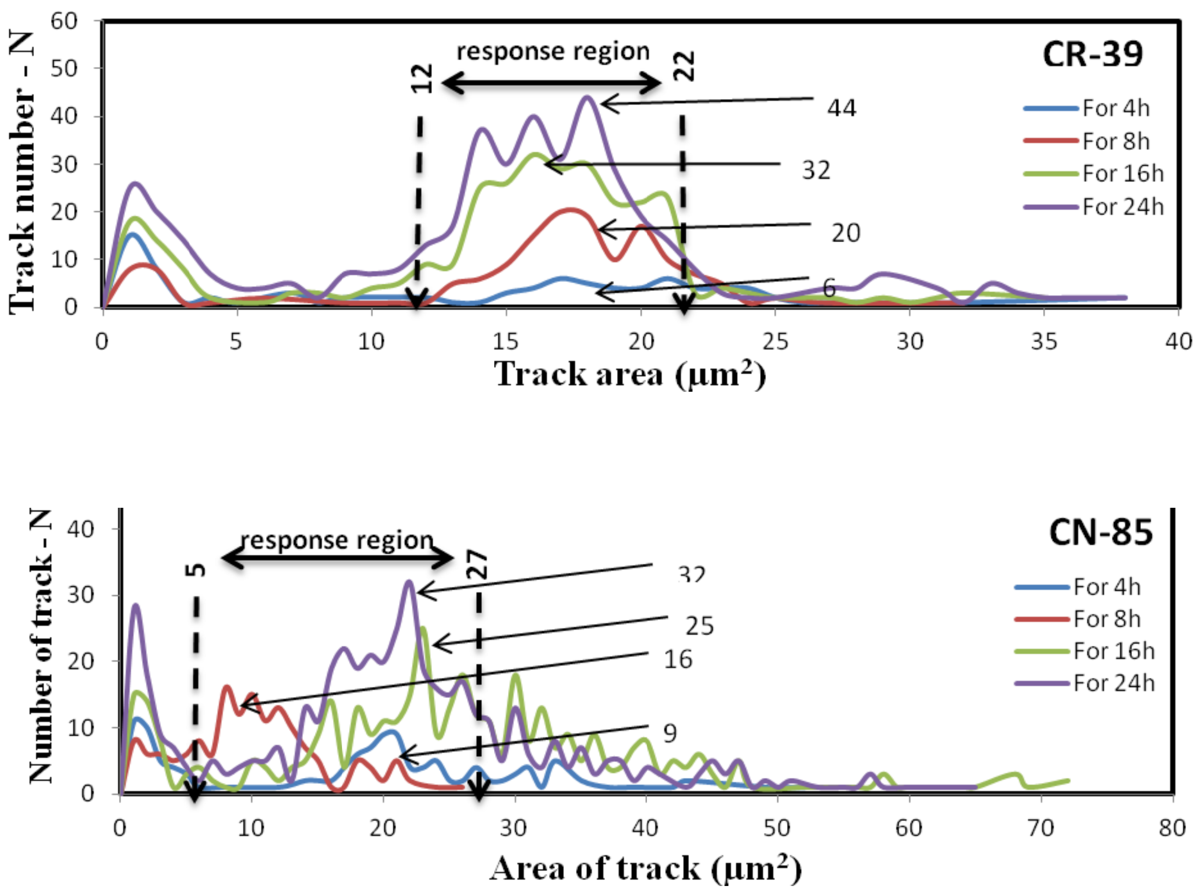

Fig.2. Relation between the track number - N with track diameter - D_T at irradiation time - T_D 4h, 8h, 16h and 24h for CR-39 and CN-85 detectors

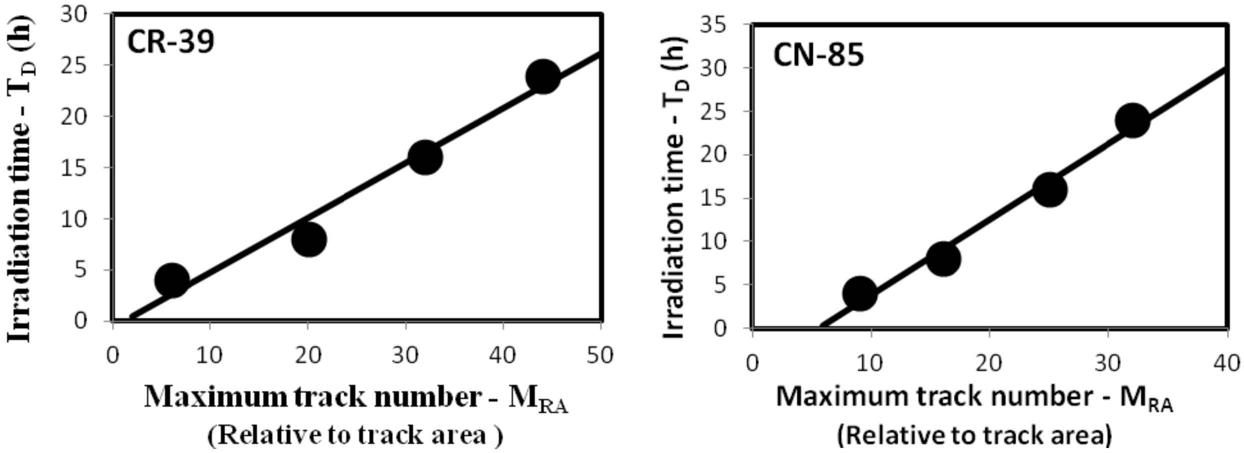

Fig.3. Linear relationships between irradiation time T_D and max. track number M_{TA} (relative to track area) at limited response region of track area , from 12μm^{2}to 22μm^2 for CR-39 detector and from 5 μm^{2}to 27μm^2 for CN-85 detector

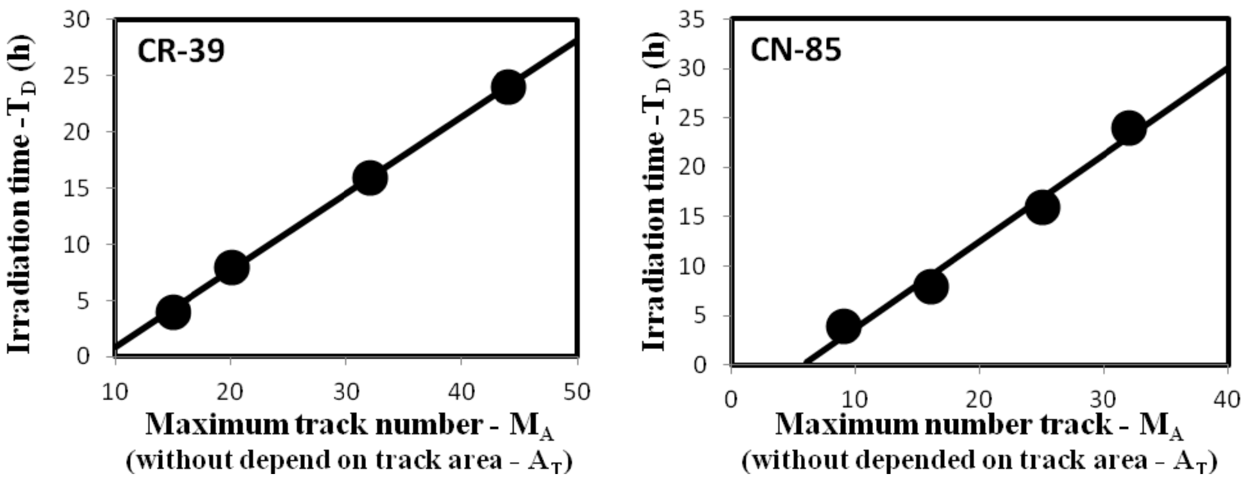

Fig. 4. Linear relationships between maximum track number - M_A with irradiation time - T_D (h) for CR-39 and CN-85 detectors