Determination of Nuclear Track Parameters for LR-115 Detector by Using of MATLAB Software Technique

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Abstract

The nuclear track detector parameters, such as nuclear track diameter D(μm), number of track N_T and area of track A_T were determined by using MATLAB software technique for IR-115 detector irradiated by alpha particle from ^{241}Am source under 1.5, 2.5 and 3.5 Mev at etching time T_B of 90, 120, 150 and 180 min.

By using the image analysis of MATLAB software for nuclear track, the full width at half maximum FWHM and relative resolution R% were calculated for each energy of alpha particles.

In this study, it was shown that increasing the alpha energy on the IR-115 detector leads to increased in etching time T_B and the dropping of R% to minimum value, and then reach a stable value before dropping at values 1.5, 2.5 Mev and unstable at 3.5 Mev. Imaging analysis by MATLAB technique which used in this study reflect good and accurate results for nuclear track detector parameters and we recommend using this technique for the determination of these parameters.

Keywords: LR-115 detector, MATLAB software, nuclear track detector, etching time.

Introduction

Image analysis technique was used for images of optical microscope to count the effects of nuclear trackdetectors by kani Garan et. al. in 1976 [1] followed by many researchers in this area [3] [2]. In 1980, measure the number of CR-39 nuclear track detectors automatically by image analysis software using a accurate programming processor [4]. Some of them admitted to the technique processor fourier optical by Flores et. al. [5] and system track analysis of nuclear automated and pseudo coloring technique [6], modeling of samples [7], system scanning of imaging [8] and digital imaging system [9].

Boukhair et. al. [10] write code a new analysis of the image using a color digital camera with CR-39 and LR-115 detectors, prompting both researchers Nikezic and Yu. [11] to develop software for the identification and mapping of nuclear track parameters. A study was conducted in Australia by Paggie 2006 [12] comparing the automated and manual systems in the calculation of the number of nuclear track and diagnosed using specific software in the computer and found that there was good agreement between the two systems to calculate the number of nuclear track. Also, Patiris et. al. [13] by writing a program TRIAC in Matlab language developed to be able to distinguish the nuclear track parameters and other parameters for nuclear detectors. The researcher was able in 2007 [14] to design of the TRIAC-II program for the diagnosis and distinguish the nuclear tracks and use the above program to study image analysis and classification of nuclear tracks depending on the diameters.

Where the fact that diagnosis of nuclear tracks specifications of nuclear is one of the important things, therefore Puglics [15] was develop a digital system in which to diagnose specifications by some factors related to the effect of nuclear tracks. While Eghau [16] was find consensus between the preparation of the effects measured using normal and digital systems. Sato et. al. [17] were developed place a monitoring system which depicts the track with time passing and the component on the surface of the detector during the process of etching. Nikazic et. al. [18] have designed a computer program to calculate the angular distribution of distortion of light on the CR-39 detector. Ioannides and Patiris [19] have using a TRIAC-II previously worked for the focus of some nuclei such as ^{214}Po.

In this study, was using the certain software program group the MATLAB [20, 22] in the analysis of microscope images of LR-115 detector after alpha irradiated with different etching times $-T_B$, and has been determination of nuclear track parameters and calculated the values of the full width at half maximum - FWHM and relative resolution - R% through those parameters.

Materials and Method

LR-115 detector was prepared with dimensions 1.2 x 1.3 cm and irradiated with alpha-ray source from the ^{241}Am source and identified alpha energies 1.5, 2.5, 3.5 Mev after calibration using the alpha system surface barrier silicon detector. Where the radioactive source is placed at distance 3cm from silicon detector and by using of polyethylene with a thickness equivalent to $1.55\text{-}3.45\text{x}10^{-3}$ g/cm^2 to reduce the intensity energy of the incident alpha, then calibration curve can be drawn between the energy of alpha and location of the incident energy by pulse generator of the system of silicon detector.

The chemical etching of LR-115 detector was performed using 2.5 N NaOH solution [20] at a temperature of 55 C^o with etching times - T_B range 90, 120, 135, 165 and 180 min. Microscope model Nikon model 205-870 with digital camera was used and has been linked to the type of digital eye pieces 35UMD-PC, and digital camera size (480 x 640 pixel) and then connect to computer. Files of images samples were stored as a joint photographic group - jpg files.

Processed of image analysis using the MATLAB software technique [21] through the use of automatic image analysis software package in the MATLAB programs. And calculated the nuclear track parameters of LR-115 detectors as intensity of the nuclear track-$I_{T,}$ track diameter-D(μm), number of tracks-N_T and the track area-A_T, In addition to the conclusion relations associated with those parameters.

Results and Discussion

The microscope digital image of nuclear track for LR-115 detector which irradiated at 3min with 1.5 Mev alpha particle and etching time 120 min was analysis using the enhancement step of MATLAB software. The background image of unwanted impurities and distortions in the image was start putting with keeping the only nuclear track and is returned to represent the true picture of the nuclear track as shown in Fig.(1A). The relationship between diameter of track-D(μm) and the track density- I_T (pixel) was drawing in Fig.(1 B). Where it is noted that the increase of the track diameter - D(μm) which followed by an increase in the thickness of the layer removed from the detector and less track density- I_T (pixel) which means the least number of pixels that it track contains.

Fig.(2A) shows the relationship between the number of track - N_T and track area-A_T in the form of a histogram in calculating number of track which compared with the number of track from program to have seen that identical. While Fig.(2B) shown the relationship between the track number -N_T and track diameter - D_T in the form of a histogram which also reflects the disparity in the diameters of track. Since the diameter of track depends essentially on the energy of incident alpha particle, so was drawn quassian distribution between the number of track-N_T and track diameter -D_T, and when fitting for the curve that the gaussian distribution shows clearly Fig.(2C).

From Fig.(3 A, B), it can be calculated at the full width at half maximum FWHM addition to determine the relative resolution - R%. Where to find both values FWHM, R% at etching times T_B 180, 150 and 90 min.

Table (1 A) shown the appearing of the track parameters for 3min LR-115 detector irradiated by 1.5 Mev at etching times- T_B (90, 120, 150, 180 min), as well as to determine both values of the FWHM and R% for each etching times-T_B. In the same way were irradiated of LR-115 detector for 3min with the energies 2.5, 3.5 Mev, and determine the values of FWHM, R% as shown in Table (1 B) and Table (1 C) for both the energies respectively.

Have been drawn the relationship between R% and the etching times- T_B for each irradiation energy Fig.(4). As noted by the figure 4 that the increase in incident energy of alpha particle on the detector which followed an increase in the etching times- T_B, also lead to a drop in the value of R% below the value of it, then start stability at that value and dropping at the energy 1.5, 2.5 Mev and volatility at the energy 3.5 Mev.

The volatility that occurred at 3.5 Mev can be explained, where that the detector after installation of that energy has led to the formation of other complex compounds contributed to fluctuations in the value of R%. Fig.(5), show the relation between the track diameter - D (μm) and the etching times -T_B of energies 1.5, 2.5, 3.5 Mev, where it notes that both energies 1.5, 2.5 Mev hardly be similar through the increase in the etching times T_B which lead to an increase of track diameter, but at 3.5Mev energy, the increase in the etching times -T_B lead to increase in the track diameter D (μm) to a certain extent up to the time of 170 min and then begin scraping stability and this can be attributed to the collapse point of the detector after that limit.

Table(1)

Nuclear track parameters, relative resolution percent R(% , full width at half maximum FWHM and track diameter D (μm) for LR-115 detector calculated by MATLAB software.

A) At the 3 min alpha irradiated with 1.5 Mev energy, etching time -T_B, 90-180 min.

R(%)	*FWHM (μm)*	*D (μm)*	*T_B (min)*	*N_T*
46.42	2.46	5.51	90	28
18	1.56	8.62	120	37
19.1	2.06	10.13	150	39
22.4	3.5	16.6	180	31

B) At the 3 min alpha irradiated with 2.5 Mev energy, etching time-T_B , 90-180 min.

R(%)	*FWHM (μm)*	*D (μm)*	*T_B (min)*	*N_T*
50.79	2.64	4.97	90	53
47.9	3.9	8.26	120	59
15.3	1.615	10.81	150	51
18.3	3.05	15.56	180	47

C) At the 3 min alpha irradiated with 3.5 Mev energy , etching time- T_B , 120-180 min.

R(%)	*FWHM (μm)*	*D (μm)*	*T_B (min)*	*N_T*
44.3	2.26	5.09	120	68
34.4	2.2	6.67	135	90
25.3	2.13	8.43	150	98
12.16	1.3	9.88	165	102
35.33	3.88	10.24	180	77

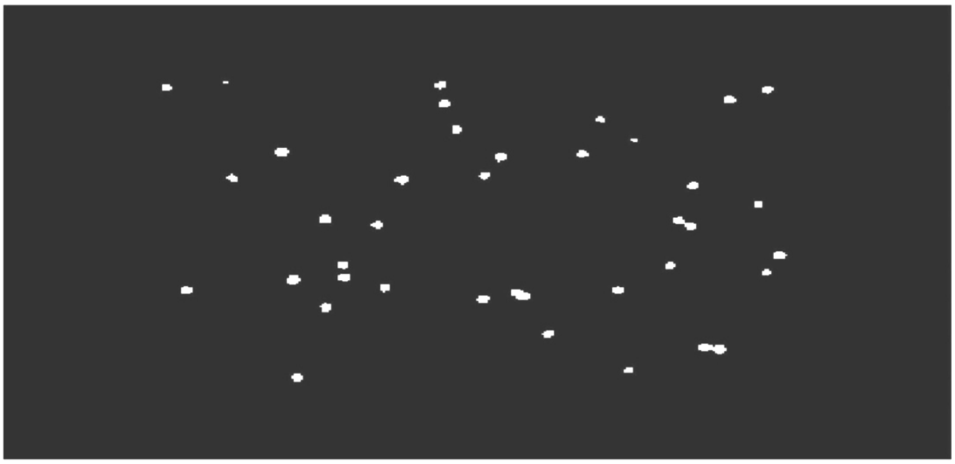

Fig. (1 A) Image analysis by MATLAB software enhancement step for photo digital camera size (480 x 460 pixel). Appear the nuclear tracks with different by measuring irradiated at 3 min with 1.5 min with 1.5 Mev alpha particle and etching time 120 min.

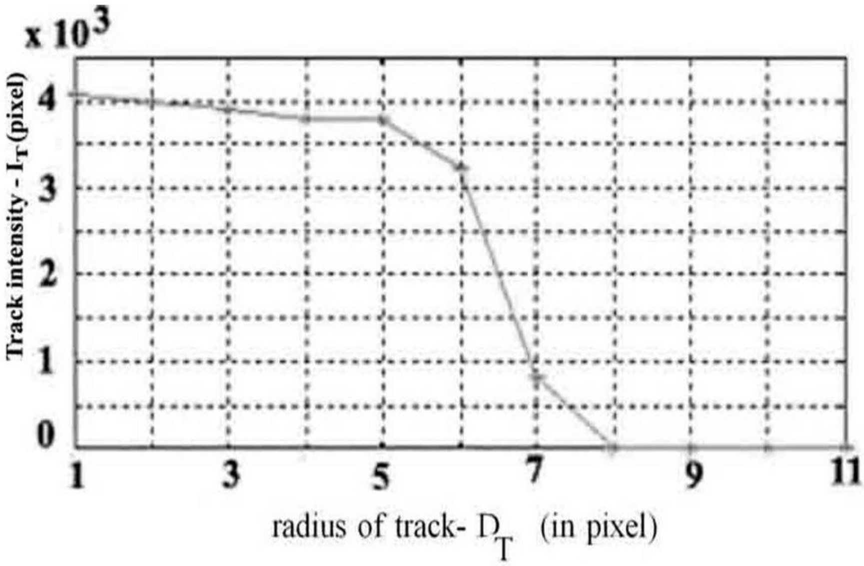

Fig. (1 B) Image analysis by MATLAB software for picture of Figure (1 A) between diameter of track-D_T (μm) and track density I_T-(pixels).

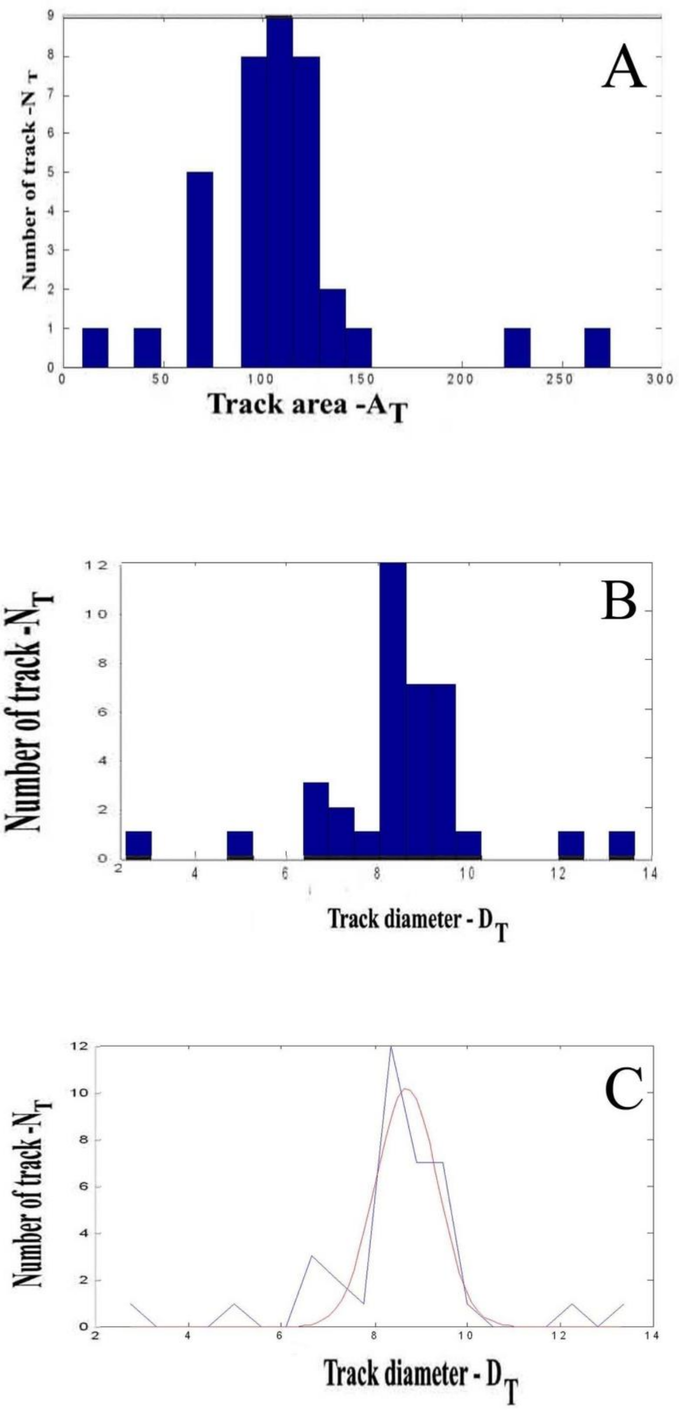

Fig. (2) Image analysis by MATHLAB software for picture of Figure (1 A) after calculated :
A: track number –N_T and track area-A_T.
B : A: track number –N_T and track diameter -D_T.
C : smoothing curve by quassian distribution between the number of track-N_T and track diameter -D_T.

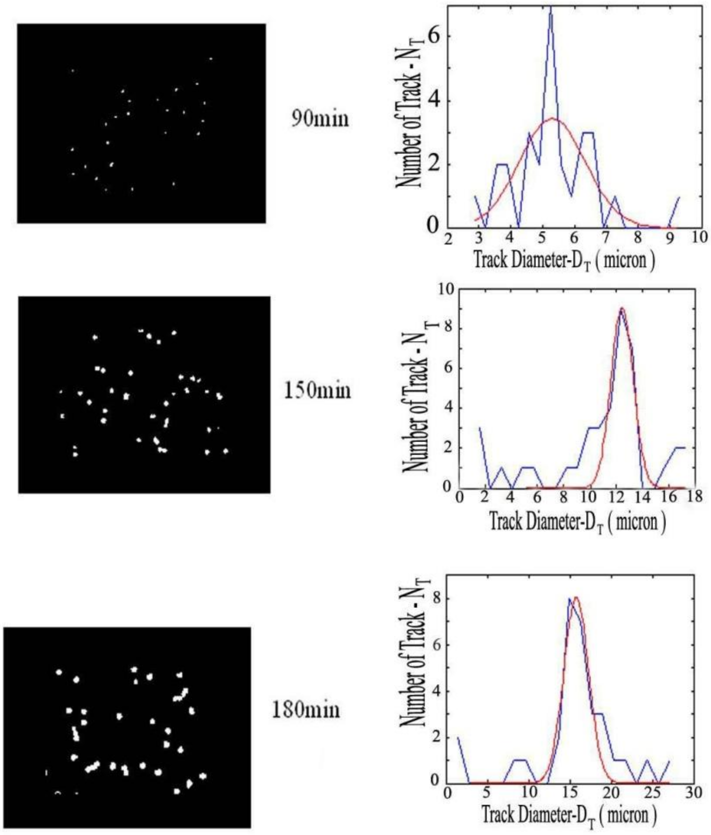

Fig. (3) A: Image for IR-115 detector irradiated 3 min with alpha 1.5 Mev at etching time 90, 150, 180 min.
B: Smoothing curve between the number of track –I_T and track diameter D_T (µm).

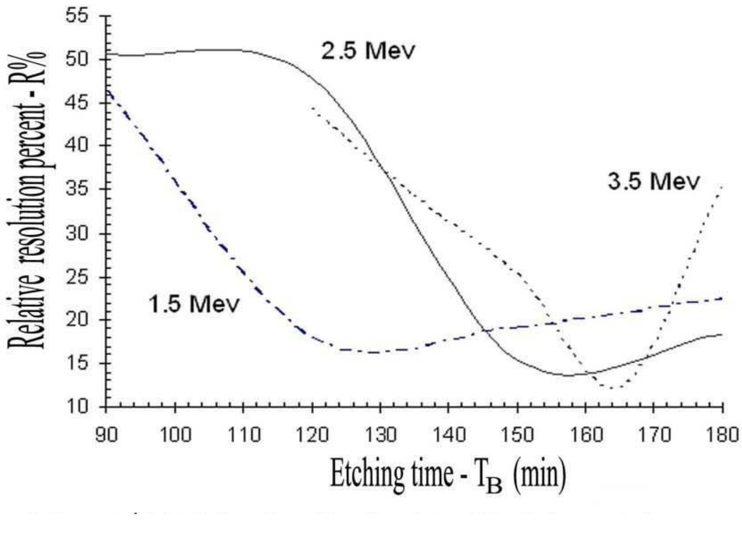

Fig.(4) Relation of etching time-TB with relative resolution percent R(%) for LR-115 detector which irradiated with energies 1.5, 2.5, 3.5 Mev of alpha particle.

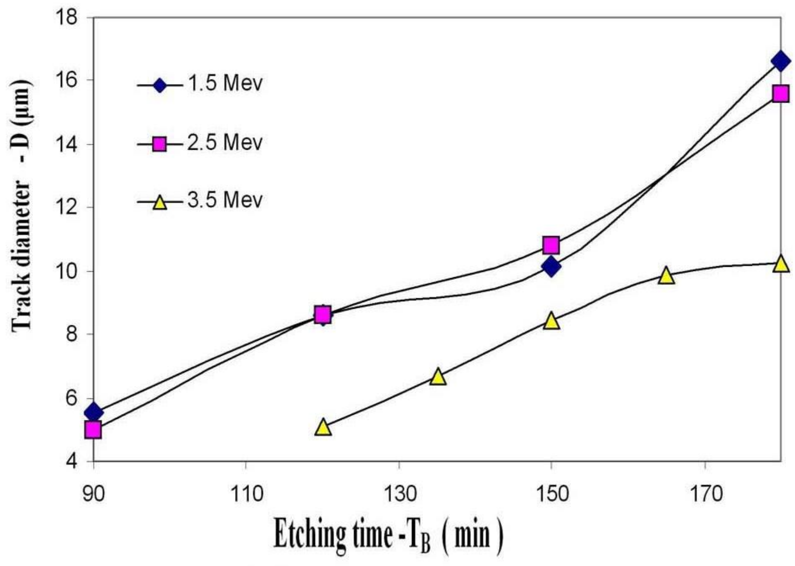

Fig. (5) Behavior of etching time-TB with track diameter-D(μm) which calculated by (Table (1)) for LR-115 irradiated with 3 min alpha partical at 1.5, 2.5, 3.5 Mev.

Conclusion

In this study, found that the use of image analysis software by MATLAB technique leads to give fast and accurate results to the values of nuclear track parameters (nuclear track diameter D_T, number of track N_T and area of track A_T) for LR-115 detector. And this is something that enhances the possibility of using this technique to other nuclear track detectors such as CN-85 and CR-39 detectors, involving the use of traditional methods in the measurement of these parameters. We recommend in subsequent studies, to using image analysis by MATLAB technique for the detectors which exposed to alpha emitters which have multiple of alpha energies. There is also scope to use this study to estimate radioactive contamination accidents in the alpha radiation in addition to the measurement of radiation doses.

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الخلاصة

تم استخدام تقنية برمجيات الـ Matlab في إيجاد معاملات الأثر النووي، قطر الأثر النووي (D (µm، عدد الآثار N_T، مساحة الآثار A_T للكاشف LR-115 عند التشـعيع من مصدر Am-241 بأشعة الفا للطاقات (Mev 3.5 , 2.5 , 1.5) ولأزمنة قشط 120 ,150 ,180 - T_B (min 90,) باستخدام التحليل الصوري لبرمجيات الـ Matlab للكاشف LR-115، تم أيجاد عرض قمة المنحني عند منتصف أعلى قيمة لعدد الآثار – FWHM في وصف للأثر النووي والتحليلية النسبية – R% لكل طاقة من طاقات أشعة الفا الساقط.

تبين من خلال هذه الدراسة بان زيادة طاقة أشعة الفا الساقطة على الكاشف والذي يتبعها زيادة في زمن القشط - T_B تؤدي أيضا إلى هبوط في قيمة R% إلى اقل قيمة لها، ثم تبدأ عند تلك القيمة بالاستقرار والانهيار للطاقتين 1.5,2.5 Mev والتذبذب للطاقة 3.5 Mev. كما تبين هذه الدراسة أيضا إن التحليل الصوري باستخدام تقنية برمجيات الـ Matlab أعطت نتائج دقيقة لقيم معاملات كواشف الأثر النووي ويمكن التوصية باستخدامها في هذا المجال.