Investigating Bragg Curve of Alpha Particles by Using Nuclear Track Detector Type Lexan

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Abstract

In the present work investigating Bragg curve for measurement of linear energy loss transfer (LET) of alpha particles in air for medical application purpose in the field of cancer treatment. The technique used for achieving measurement was nuclear track detectors and by using track geometry. Detector used was lexan and the source of alpha particles was ^{241}Am at energy 4.5 MeV. The transmission curve was established and position of the peak determined, which that correspond to occurrence of maximum energy loss transfer in air. The results indicated an approachment between the experimental results and the theoretical results. The present study show a possibility to used lexan detector to characterize the LET for heavy charge particles for used in medical fields, application.

Key Words: Alpha Particle, Track Diameters, Lexan Detector, Linear Energy Loss Transfer LET, Bragg Curve and Stopping Power.

استقصاء منحني براك لجسيمات الفا باستخدام كواشف الاثر النووي نوع اللكسان

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بغداد- العراق

الخلاصة

في هذا العمل تم استقصاء منحني براك لقياس الفقدان الخطي (LET) لطاقة جسيمات الفا في الهواء لإغراض التطبيقات الطبية في مجال معالجة السرطان . التقنية المستخدمة لانجاز هذا القياس كانت كواشف الاثر النووي وبالاعتماد على هندسة الاثر. الكاشف المستخدم هو كاشف اللكسان ومصدر جسيمات الفا هو ^{241}Am بطاقة 4.5 MeV . منحني النفاذية تم تحقيقه وتم تعين موضع القمه فيه والذي يمثل اعلى فقدان للطاقة لجسيمات الفا في الهواء. النتائج أشارة الى وجود تقارب بين النتائج العملية والنتائج النظرية. العمل الحالي بين امكانية استخدام كاشف اللكسان في توصيف الفقدان الخطي للجسيمات المشحونة الثقيله للاستخدام في المجال الطبي.

الكلمات المفتاحية : جسيمات الفا، أقطار الاثر، كاشف اللكسان ، فقدان الطاقة الخطي ، منحني براك وقدرة الايقاف.

Introduction

The use of alpha particles in treating cancer was limited because of the difficultly and ability to use α-particles in fighting cancerous cells (Mclaughlin,*et al*.,2013) But now the scientific development has enable using to control the transfer of alpha-particles. Therefore, researches interest are increasing in the study of energy loss of these particles (Rice, 2013).Alpha particles are able to more aactivity destroy cancerous cell and able to do without more damage to surrounding tissues. The nuclear track detectors technique consider important for the detection of heavy particles due to of their capacity to record at trace of these particles (Fleischer,*et al*.1975), which than we can show these traces by using suitable chemical solution (Durrani,*et al*.,1987).

In recent years there has been increased attention by the under able dose through using radiation for treatment of cancer cell especially when applying the secondary neutrons generated in proton therapy (Barth,2003) and the possible effects on pacemakers (Barth,2003 and Ferrari,*et al*.,2007). Nuclear track detectors technique used of determination of linear energy transfer, which is consider as sensitive to heavy charge particles and so they can be used in various application (spurny,et al.,1996). Lexan polycarbonate is a promising polymer having high transparency in the visible spectrum ray, therefore its used in different optical application (Anthony, ,1985) and other applications in medical, electronic, space application and characterize ion track (Raj,*et al*.,2011).

In this study the principal concern characterizes rate of energy loss of alpha particles by applying nuclear track detector technique and actualizing of the experimental programs that support the uses of charge particles for treatment cancer cell in the Iraq institutions, which is denationalizing for medicals purpose.

The aim of this study was Investigating Bragg Curve by used lexan detector and study the relation betueen number of track and bragg curve .

Materials and Methods

1-Approach Theoretical

When heavy particles is passing through matter, it loses its energy, but stopping power describes only the energy loss of charged particles. Since the production of an ion pair requires a fixed amount of energy (Soltaini,*et al*,2011),the stopping power of matter was equal to the loss of energy (E) per unit path lengthy, where:

$$S(E) = -\frac{dE}{dx} \text{ .... } (1)$$

The damage usually increasing in the end of range and reaches a maximum the bragg peak shortly before the energy drops to zero, as in Figure (1), which is represented Bragg curve.

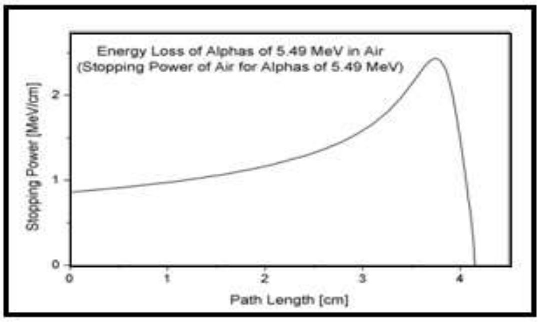

Figure (1) Represents Bragg Curve (Soltaini,*et al*,2011)

The average range is defined as the distance, which work on stopping half of falling particles on the materials, Figure (2) called permeability curve, which is represent the intensity of radiation vs thickness of matter (Melanghin, *et al*.,2013):

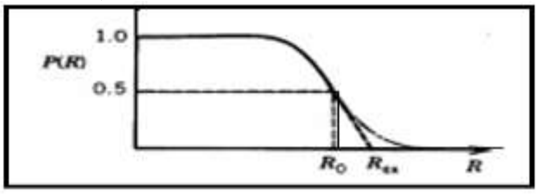

Figure (2) Represent permeability curve

when using nuclear detectors to record the alpha falling, there were two different diameters of track (Khalifa,*et al*.,2008). The ration of large diameter to small diameter was proportion with dE/dx (Rice,*et al*.,2013)

$\frac{\rho_\beta}{\rho_\varsigma} \alpha \frac{d_E}{d_x}$ .... (2)

Where :ρ_β average of large diameter.

ρ_ς average of small diameter.

And $\frac{\rho}{\rho_o} \alpha \frac{I}{I_o}$..............(3)

where:

ρ: the number of track with on detector.

ρ_o: the number of particles emitted from source.

I:intensity of falling particles

I_o:intensity of source

Therefore we can achieve Bragg curve and permeability curve by used nuclear track detectors.

2- Experimental Details

The measurement of energy loss transfer achieved by applying lexan detectors, which have chemical structure $C_{16}H_{14}O_3$ and showed in figure (3).

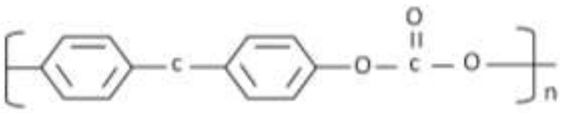

Figure (3) Chemical Structure of Lexan Polycarbonates (Anthony,*et al*.,1985).

The sheets of lexan was manufactured . Chan zobou weldin, with thickness of 500 µm, were cut into dimension of (2 x 2) cm^2. The source of alpha particles was ^{241}Am at energy 4.5 MeV.

Experiment performed at room temperature and atmospheric air. Figure (4) illustrate the components of the trying several of lexan detectors offered to sudation source of Am-241 at different distances by using aluminium pelage at different lengths from (1 to 4)cm and diameter about 1cm, which was represent the thickness of air between source and detectors.

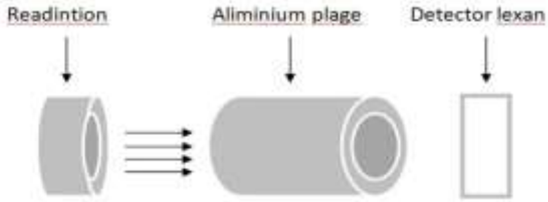

Figure (4) Represents the Components of Prosing

The time of exposure is 1 hours and the detectors were etched with NaOH solution at normality of 6N and temperature at 70 ^{o}C for 3 hours. To show the track density using optical microscope at magnification force of 500.

Results and Discussion

Figure (5) represented the image of detectors at different distance. Clearly, the number of track at distance(1.0 cm) large because the detectors nearest to the source of alpha particles. This is a large number of tracks continue to (3) cm and than its decrease and reach to zero at (4) cm,this could be due to the air become able to stop alpha particles with increase the distance.

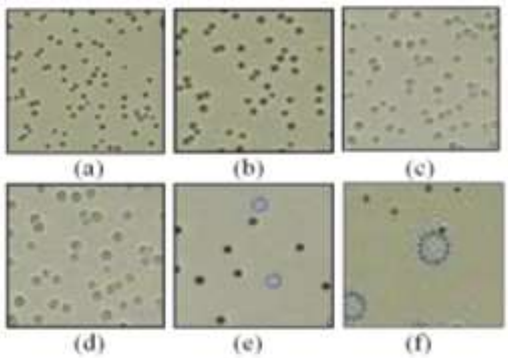

Figure (5) Microscope image of all Detectors at (a) 1 cm (b) 2 cm (c) 3 cm (d) 3.5 cm (e) 3.7 cm (f) 4 cm

The relationship between track density and distance between source and detector was shown in Figure (6). So the track decrease with increase distance. This is due to the range of alpha particles in the air, which was about (3-4) cm (Cherry,*et al*.,2012).

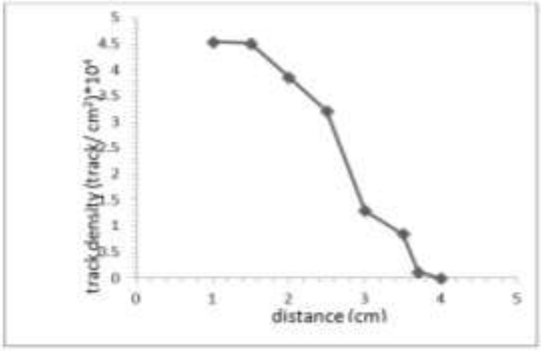

Figure (6) The Relationship between Track Density and Distance

Figure (7) represent another description of Bragg curve, where we separated the large diameter, which was represented high energy of alpha particles from small diameter, which was represent low energy. Ability to notice that the air can be stopping the particles have low energy with increasing distance, therefore the curve represent average of small diameters was less from the curve represent the average of large diameters. The increasing in average of diameters were continue to (3.5) cm, where the particles of alpha loss all their energies and then the density of diameters descend to zero.

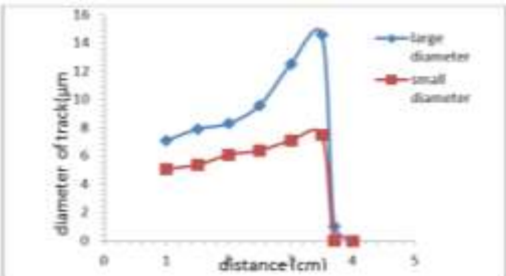

Figure (7) The Relationship between Distance and the Diameter(Large and Small)

Figure (8) indicated the relationship between the ratio ρ_B/ρ_S and the distance between the detector and source.The results in figure (8) illustrated the ratios were increasing after distance (2.8) cm, until it reaches to maximum value at (3.9) cm and then decreasing until it reached zero.

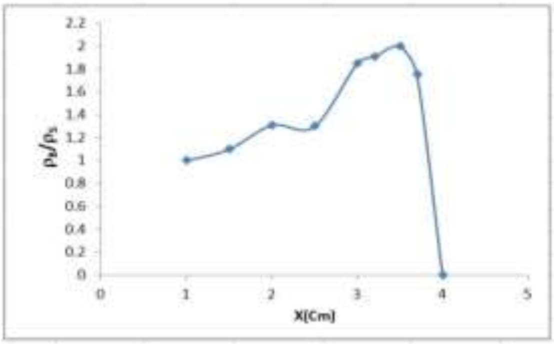

Figure (8) The Relationship between Ratio of Track Diameter and Distance.

The source of alpha particles represented average of energy of the particles, which was equal to (4.5) MeV , at distance of (1.0) cm the air can stopped number of particles ,which have low energy that was led ρ_ς become small and the particles have high energy reach to detector and then ρ_β constant because the air can't stopped it (high energy), therefore the ratio $\rho_\beta/\rho_\varsigma$ is increasing. After (3.9) cm energy of alpha particles was weak and then ρ_β become small until become zero. Curve indicate that the for shape of bragg curve was small which was corresponds to the occurrence of

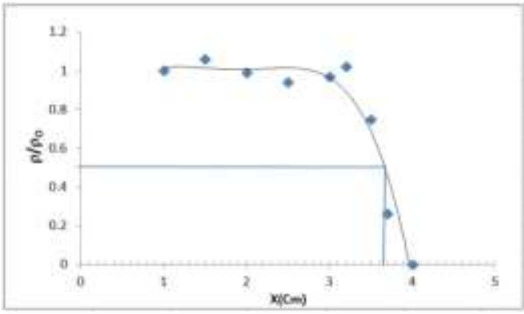

Figure (9) Indicates to the Relationship Between the Ratio of Particles number and Distance.

maximum energy loss in air at position of peak. Figure (9) explains the value of ρ/ρ_o vs the distance between source and detectors, which represents the permeability curves as a results of transfer α-particles in straight paths.

The α-particles didn't reach to the detector after (3.3) cm, because the air became stopping the particles and for each the increasing thickness the number of α-particles decreasing until reach zero From the curve it was possible to calculate the average of α-particles in air, which was about (3.7) cm. This was value compatible with theoretical value for the same energy of alpha particles ,this is indicate that the experimental value of a range of alpha in air was (3.7) cm (Cherry,*et al*.,2012)

Conclusions

1- The possibility of using nuclear track detectors to characterize the energy loss transfer of heavy charge particles .

2- Ability of using nuclear track detector to determined the range of α-particles in air to determine the distance which is happens at it maximum loss of alpha energy for medical application

3- Applying the nuclear track detector we can study the human tissue to determine the suitable energy for the doses used in treatments the cancer.

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