Calculation of Optical Energy Band Gap of CR-39 SSNTD irradiated by Alpha particle

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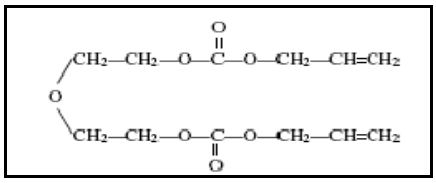
Abstract
The effect of alpha particle irradiation on the optical absorption in nuclear track detectors (CR-39)has been studied . These detectors have been irradiated with different doses. The optical absorption has been measured using the ultraviolet-visible (UV-1100) spectroscopy, this irradiation results in Shifting the peaks of the optical absorption. The values of Urbach energy have been calculated from the position of steady-state optical band gap energy, and the values of this energy for standard sample and the which irradiated in indirect influence where it is found to be(3.9eV) before irradiation and the least value after irradiation(3.2eV).In case of the indirect influence, it is found to be respectively before irradiation (4.2eV)and after irradiation (3.8eV) . From these results we can reveal that ,the values of energy gaps in direct –coincidence greater before and after irradiation from those in indirect. The energy gap is inversely proportional to the absorbed doses ,i.e the energy decreased with increasing the dose, and this because the irradiation Effects. Finally, the number of carbons atoms have been determined in each case for the optical energy gaps.
Key word :- CR-39 ,optical energy gap, alpha particle

Introduction
The SSNTD we used was the CR-39 polymer (Poly-Allyl-Diglycol-Carbonate),which is an optically transparent, amorphous, there most plastic with a high degree of isotropy. The principal reasons for using it were its unique sensitivity and uniform response. Track detecting plastic spossess many advantages over electronic detectors. In particular spatialre solution of a few microns is available simultaneously with the potential for high-resolution spectroscopic measurements. Other advantages are cheapness, ease of use, ability to provide a permanent record of events, and the ability to operate in adverse environments. For these reasons used the CR-39**.**[1].Polymers have proven potential in all fields during the last few decades. Different studies of the effect of irradiation on polymers, reveals a variety of modifications of the physical and chemical properties such as optical, electrical ,mechanical etc. of polymeric materials depending on the irradiation influence and the energy of the radiation used. Interaction of radiation or highly energy etic charged ion strikes a polymer target; it loses most of its energy in exciting or ionizing the atoms along its trajectory. Target ionization causes bond cleavage (scission), cross-linking, degradation, emission of atoms and molecules, creation .[2] . Ion beam bombardment is a suitable tool to modify the physicochemical properties of polymers. Poly- known polymer, isused in diverse fields such as neutron dosimetry, gamma and cosmic ray detection, heavy ion and nuclear physics. CR-39 is transparent in visible spectrum and almost completely opaque in infrared and ultraviolet range. It has high abrasion resistance, about half the weight of glass and index of refraction only slightly lower than that of crown glass. This makes it an advantageous material for eyeglasses and sunglasses[3]. A wide range of colors can be achieved by dyeing the surface or the bulk of the material. The use of ion beams to modify polymer properties opened a wide area of research and utilization in various fields like industry, agriculture, ecology, sensorics, microelectronics and nanotechnology. The damage processes triggered by ions can be different from those induced by classical low ionizing particles as electrons or gamma rays. This is due to the very high electronic stopping power of these ions. A gradual increase in absorbance], generation of chromophoric groups, loss of crystallinity, formation of carbonized inclusions along with a gradual phase transition, as well as creation of three-dimensional network and triple bonds] have been found in polymers due to ion bombardment. In most cases the amount of energy deposited in the host polymer is enough for extensive breaking of the chemical bonds within the track, which makes that strong modification of the bombarded polymer material, is possible. The energy released by the ion during slowing down is deposited in the target by means of two basically different mechanisms, electronic excitationand nuclear collision, which induce quite different processes of polymer matrix rearrangement [4,5,6]

2. Experimentalprocedure
CR-39samples of thickness (595μm) were irradiated with different alpha particle doses using ^{210}Po source. The samples (2×1cm) were irradiated for various times and the total alpha doses obtained were listed in table (1).The nature of the optical modifications of the pristine and alpha irradiated CR-39 polymer Samples were subjected to spectral studies in the Ultraviolet and visible region. These studies were carried out by using (ChromTech,USA) Specetro-photometer (UV1100) in the wavelength range of (240-840 nm)



3. Results and Discussion

The optical absorption spectra of pristine and alpha irradiated CR-39 samples were recorded using(UV-visible) spectro-photometer in the wavelength range (240-840nm)at room temperature .From these spectra displayed in fig(1),it Is clear that a shift of absorption edge to words longer wavelength with increasing alpha absorbed dose can be readily observed. The absorption peak with increasing dose is seen to change into a broad one . The behavior is generally inter- preted as caused by the formation of extended systems of conjugate bonds .i.e Possible formation of carbon cluster. The absorption bands in the investigated range of wavelength are associated to the(π-π*)electronic transition. This type of transition occurs in the unsaturated center of the molecules .i.e in compounds containing double or triple bonds and also in aromatics. The excitation of(π)electron transition requires smaller energy and hence, transition of this type occurs at longer wavelengths.[5]

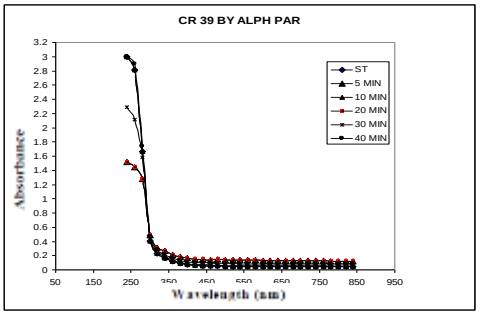


Fig. (1): UV–visible spectra of the pristine and alpha-irradiated CR-39

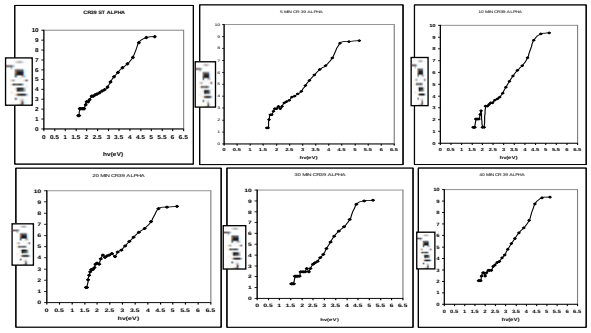
The optical absorption confficient (α) was calculated from the absorbance,(A)after correction for reflection losses, **(α)** may be obtained using the following equation [1]:

α(ν) = 2.303A/l ……(1)

Table 1: The variation of band gap energy and Urbach's energy in the prisitine and alpha irradiated CR-39,along with number of carbon atoms.(N) per conjugated length

Time (min)	Alpha dose (mGy)	Band gap energy (eV)		Urbach's energy (eV)	No. of carbon atoms (N)	
		indirect	Direct		indirect	Direct
0	0.18	3.8	4.4	0.7	5	4
5	0.9	3.6	4.1	0.5	5	4
10	1.8	3.5	4.1	0.45	5	4
20	3.6	3.4	4.0	0.55	5	5
30	5.4	3.3	3.9	0.6	6	5
40	7.2	3.2	3.8	0.45	6	5

Where l is the sample thickness in cm A is defined by $A=\log(I_o/I)$ where I_o and I are the intensity of the incident and transmitted beams, respectively.



Fig(2): The dependence of natural logarithm of a on photon energy for pristine and alpha irradiated CR-39 polymer

The logarithm of the absorption coefficient α(*v*) was plotted as a function of the photon energy (*hv*) for CR-39 irradiated with different doses of alpha as in fig(2).The values of the Urbach's energy (Eu) were calculated by taking the reciprocal of the slopes of the linear portion in the lower photon energy region of these curves and listed in Table(1). The decrease in the Urbach's energy in case ofCR-39 may be due to the decrease in the crystalline nature of the polymer. The Urbach's energy sharply decreasing with increasing alpha doses. This sharp decrease indicates the irregularization of the band gap energy level; furthermore this is due to amorphous nature of CR-39 polymer. The decrease in band gap energy attributes to the decrease in the resistively of CR-39.This means that there is change in the structural characteristics of CR-39 as a result of alpha irradiation(the values of energy gap in the case of indirect transitions, in most cases are lower than the energy gaps of direct transition, due the presence of delocalized states between valance band and conduction band)[2,4]. It may accounts for the scission of the polymer chain and formation of free radicals. It is a decreasing trend of energy gap with increasing alpha dose. This is due to carbon enriched domains created in polymer during irradiation. The usual method for the determination of the value of(E_g) involves plotting $(\alpha h\nu)^{1/n}$against (*hv*).Indirect transition in many amorphous materials fit the case for *n=2*; for a direct reasonable fit with *n=1/2* is achieved .In the present study the most satisfactory results were obtained by plotting $(\alpha h\nu)^{1/2}$and$(\alpha h\nu)^2$ function of photon energy*(hv)* respectively, taking into account the linear portion of the fundamental absorption edge of the UV-Visible spectra.Band gap in polymer .i.e direct and indirect have been determined for pristine and alpha irradiation CR-39 polymer and shown in figures(3) and (4). The values of the indirect and direct band gap (Eg) for pristine and alpha irradiated sample.

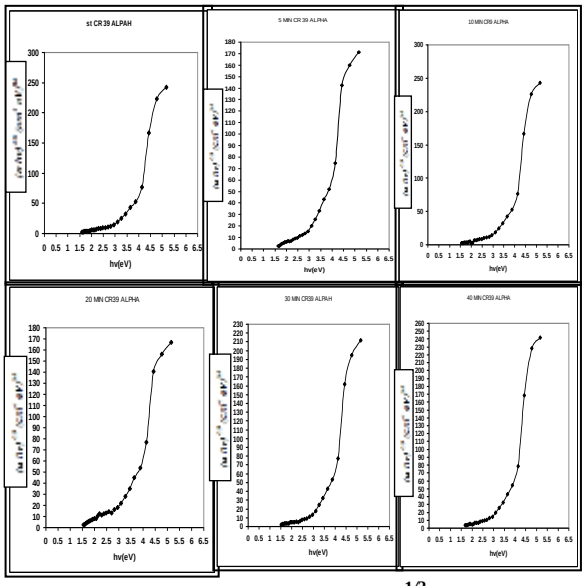
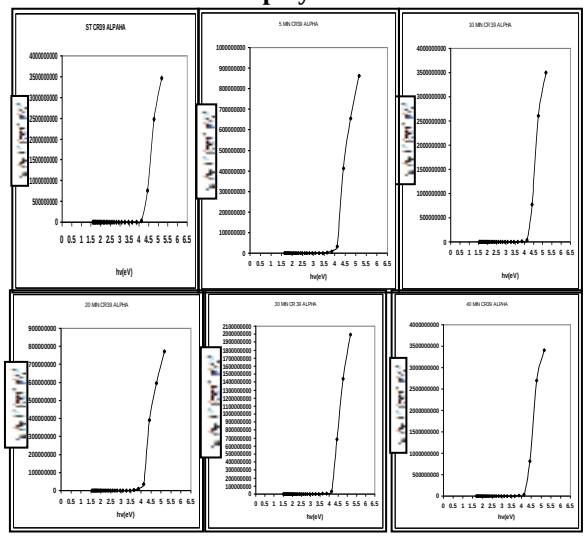


FIG. 3: The dependence of $(ahv)^{1/2}$ on photon energy (hv) for pristine and alpha irradiated CR-39 polymer



Fig(4): The dependence of$((ahv)2$ on photon energy (hv) for pristine and alpha irradiated CR-39 polymer

Furthermore, the values of indirect band gap have been found to be lower than the corresponding values for the direct band gap as shown in(Fig.5).The simultaneous existence of indirect as well as direct band gap in CR-39 polymer has rarely been reported[2], Pristine CR-39 is transparent and has very little absorption .Upon irradiation, the colorless surface became light brown as the gamma dose gradually increased [2,7] . For a linear structure, the number of carbon atoms per conjugation length N is given by[5]:

$N = 2\beta\pi/E_g$…… (2)

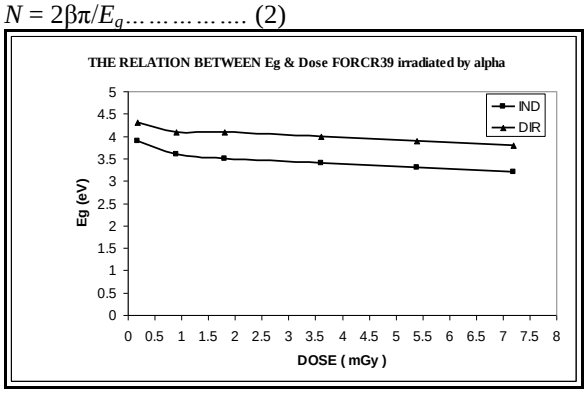


FIG. 5: Plots for Energy gap(transition energy) (eV) as a function of alpha absorbed dose (mGy).

Here 2β gives the band structure energy of a pair of adjacent π sites.The value of b is taken to be(2.9eV) [5]as it is associated with(π-π*) optical transitions in (–C = C–) structure. As the shift of the absorption edge can be attributed to an increase of the conjugation length without formation of new lengthy linear conjugated structures, Eq. (2) is applied in the present study**[5]**

Conclusions:-

Significant change are observed in optical response of theCR-39 polymer After irradiation experimental study of pristine and alpha irradiationCR-39, the value of the optical band gap(Eg) and Urbach's energy(E_u)Were determined from the optical absorption spectra. It is concluded that the values of the indirect band gap are lowerthanthe corresponding values of the direct band gap in pristine and alpha irradiatedCR-39 polymers .Also the band gap(Eg) decreases with the increases alpha doses due to the degratin of CR-39 and the formation of defcts and clusterin the material,while the cluster size increase with increase doses for both the cases.

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حساب حزمة فجوة الطاقة الضوئية لكاشف الأثر النووي CR-39 المشعع بجسيمات ألفا.

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الملخص

ان تأثير جسيمات ألفا على الامتصاصية الضوئية في كواشف الأثر النووي CR-39. بعد أن تم تشعيعها بجرع مختلفة وحيث تم استخدام جهاز (UV-1100) لقياس الامتصاصية الضوئية، لوحظ القمم للامتصاصية الضوئية بسبب التشعيع، وتم حساب قيم طاقة بلوخ((*Eu*)) من مواقع الحالات المستقرة لطاقة الفجوة الضوئية،وقيم طاقة الفجوة الضوئية للعينة القياسية والمشععة في الحالة الغير المباشر حيث كانت قبل التشعيع(3.9eV)وأقل قيمة بعد التشعيع (3.2eV) وفي حالة المباشرة كانت قبل التشعيع (4.2eV) وأقل قيمة بعد التشعيع (3.8eV) ومن ذلك نجد ان قيم طاقة الفجوة في الحالة المباشرة تكون أكبر قبل وبعد التشعيع من طاقة الفجوة في الحالة الغير المباشرة. ووجد إن طاقة الفجوة تقل مع زيادة الجرعة الممتصة، ويعزى سبب ذلك بسبب الآثار التي حدثت من جراء التشعيع وكذلك تم إيجاد عدد ذرات الكاربون في كلتا الحالتين لطاقة الفجوة الضوئية.