UV-radiation Dose Assessment for Lexan Track Detector by Using of UV-visible and FTIR Spectroscopy Techniques

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Abstract

In the present work, studies the effect UV-radiation dose(1 J/cm²- 360 J/cm²) with power 15 W to Lexan track detector thickness175 µm. Absorbance –A was measured at wavelength 300 nm and 305 nm by using UV-visiblespectroscopy and measure the transmission percent–T% and deviation at the wave number-w 940cm^{-1} by using Fourier infrared –FTIR spectroscopy. The relationship between the radiation dose of the UV-radiation (J/cm²) and the absorbance-Aat wavelength 300 nm and 305 nm and the wave number-w 940 cm^{-1} was calculate as a polynomial relation .The present study show that there is a possibility to use the detector Lexan to assessment doses of exposure to UV-radiation in the medical and environmental fields .

Keywords: Track Detector; Lexan; UV; UV–visible; FTIR.

Introduction

Lexan polycarbonate its chemical structure $C_{16}H_{14}O_3$ is shown in Fig.(1) is a promising polymer having high transparency in the visible spectrum range, which is used in all fields of life viz. optical[1], medical, electronic, space applications and for recording ion tracks [2] where its low weight, chemical inertness, high impact resistance and relatively low cost are of major importance. During the last few decades, some materials like metals and ceramics have been replaced by polymers because of their superior advantages. However, some features of polymers should be modified ionizing radiation, laser or UV-radiation [3] could be used for this purpose.

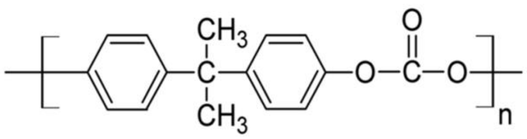

Fig.(1) Chemical structure for Lexan [1].

The changes induced in the polymer by UV-radiation depend on the time of exposure and also on the wavelength of UV-radiation. In case of short wavelength UV-irradiation, the energy is sufficient enough to break polymer bonds leading to scission of the polymer chains. In addition, depending upon the polymer structure, the free radicals generated may combine with other radicals resulting in cross-linking. UV-irradiation effects on polyallyldiglycol carbonate-PADC detector have been studied by Tse et.al, [4]. Dwaikat et.al, [5] studied the effects of UV-laser lightat λ: 266 nmand incoherent UV- radiation at λ: 254 nm onthe properties of CR-39 polymer. The mechanical and surface morphological changes of PMMA by UV-radiation have been studied by Eve and Mohr [6].

The radiation induced changes of the properties of polymer are very specific with respect to the type of polymer, radiation and its environment. The polymers which are difficult to process by chemical methods can be easily modified using UV or gamma radiation [7]. This leads to changes in structural [8], thermal, optical and surface morphological properties [9] due to radiochemical alterations such as unsaturation, evolution of gases, creation of defects, amorphization, etc. As a result, irradiation of polymers his shown great potentialin many fields such as microelectronics, biomedical, device technology nano-materials and materials science [10]. Literature survey indicates that the effects of gamma radiation on Lexan polycarbonate are being extensively studied [11]. It was further observed that there was a substantial chemical and thermal modification in the Lexan polycarbonate sample, such as breaking of C–O single bond and formation of phenolic bond and gradual decrease in the glass transition temperature, with the increase in ion fluence of 100 MeV silicon ions [12].

As per literature survey, until now, no study has been carried out on the characterization of structural, optical and mechanical modifications of UV-irradiated Lexan polycarbonate. Therefore, in the present investigation, an attempt has been made to study the effect of UV-radiation on the above-mentioned properties of Lexan polycarbonate using x-ray diffraction, Fourier transform infrared-FTIR spectroscopy, scanning electron microscope-SEM, differential scanning calorimetry-DSC, UV–visible spectroscopy, impedance analysis, tensile testing and rheometry analyses. An attempt was also made to correlate the results with reported data to make the present work more informative from a scientific point of view [13]. Lexan detector was used to assessment UV-irradiation dose by using UV-visible and FTIR spectroscopy technique.

Experimental Procedure

Lexan nuclear track detector, sheets is (the factory of the company Co. Chan Zhou Weldin) with thickness 175 µm, were cut into small pieces of 2cm ×2 cm. The source of UV-radiation was model FLUO-LINK FLX system from transilluminator with wavelength 254 nm and 15 W the power.

The distance between source of UV-irradiation and samples was 4cm, UV-irradiation doses were 1,5,30,60,120,240 and 360 J/cm² ,UV-irradiation for all samples was carried out in air and at room temperature.

Results and Discussion

1. *UV–visible spectroscopy analysis*

Fig.(2) shows the increase in absorbance-A of the Lexan samples which measured by UV-visible technique at the range 290-330 nm to the samples of Lexan with increase irradiation dose of UV-radiation at the range 10,60,120,240 and 360J/cm² compared with un-irradiated sample. This figure shows the increase in absorbance-A with increase of radiation dose. The maximum in absorbance-A with irradiation dose were appear at the wavelengths 300 nm, 305 nm as shown in Fig. (3) and Fig. (4) respectively.

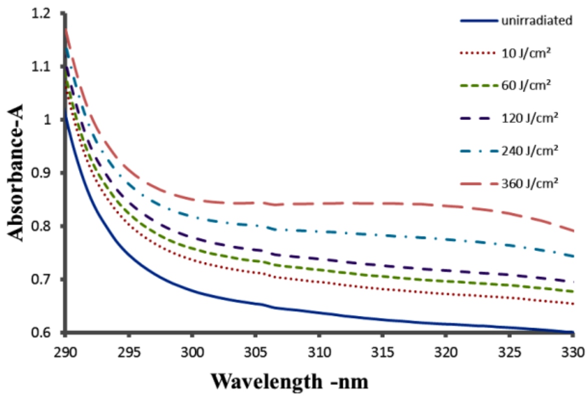

Fig.(2) Absorbance-A by UV-visible spectroscopy technique with Wavelength range (290 – 330 nm) for un-irradiated and UV-irradiated at dose range of 10,60,120,240, and 360J/cm² for Lexan detector.

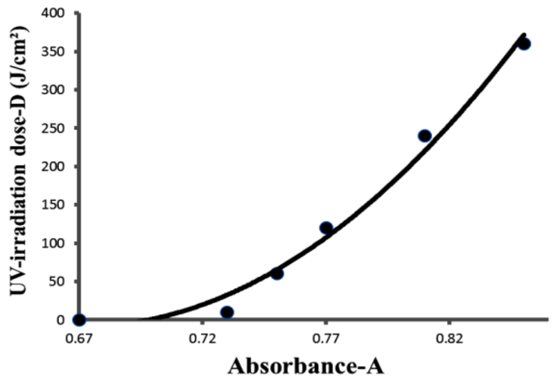

Fig.(3) Absorbance-A vs. UV-irradiation dose-D (J/cm²) for Lexan detector at wavelength 300 nm .

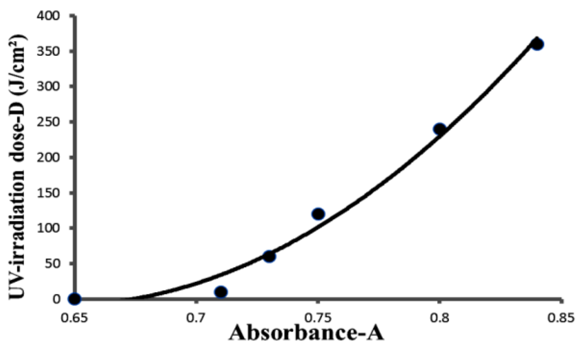

Fig.(4) Absorbance-A vs. UV-irradiation dose-D (J/cm²) for Lexan detector at wavelength 305 nm .

Fig. (3) and Fig. (4) shown the polynomial relationship between the absorbance-A and UV-irradiation dose at 300 nmand 305 nm respectively. Which are described equation (1) and equation (2).

$D(J/cm^2) = 1\times10^4A^2 - 1\times10^4A + 5.7\times10^3$ ...... (1)

$D(J/cm^2) = 9.2\times10^3A^2 - 1\times10^4A + 4.7\times10^3$ ... (2)

where D(J/cm²): UV- irradiation dose, A: Absorbance

The maximum response of UV-radiation dose 360 J/cm² at wavelength 305 nm was calculated at absorbance-A value 0.84 as shown in Fig. (4). The change in absorbance-A at 300-305 nm was also happen when determine comparison between solar UV-simulator and overhead sun for CR-39 [14]. And this change in absorbance-A at 305 nm was happen as result of attributed to the formation of conjugated system of bonds due to bond cleavage and reconstruction supporting the structural and chemical modification in PC (Lexan) after irradiation [13].

2. *FTIR-spectroscopy analysis*

FTIR-spectrum in Fig.(5) shows the change that appears in transmission percent–T% which measured by FTIR-spectroscopy technique at wavenumber range400–3800 cm⁻¹ to the samples of Lexan which irradiated by UV- radiation at range1,5,10,60,120, 240 and 360 J/cm² compared with un-irradiated sample. The change in the shape of FTIR-spectrum with irradiation dose (J/cm²) appear in wavenumber-w 940 cm⁻¹ as shown in Fig.(6).

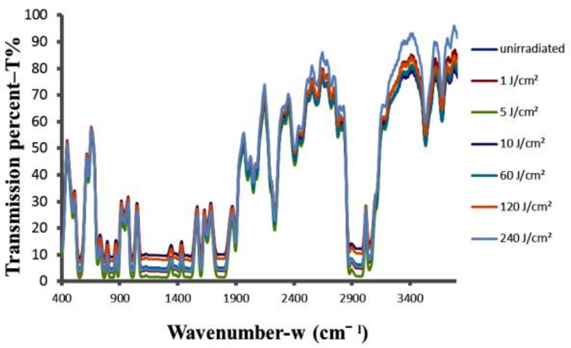

Fig.(5) Transmission percent –T% with wavenumber-w(cm⁻¹) from FTIR-spectroscopy technique for un-irradiated and UV-irradiated at dose range 1,5,10,60,120,240 and 360J/cm²for Lexan detector.

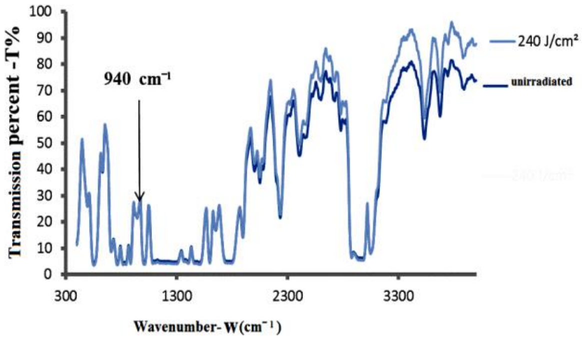

Fig.(6) Transmission percent– T% with wavenumber-w(cm⁻¹) by FTIR spectroscopy technique for un-irradiated and UV-irradiated at dose 240 J/cm² for Lexan detector.

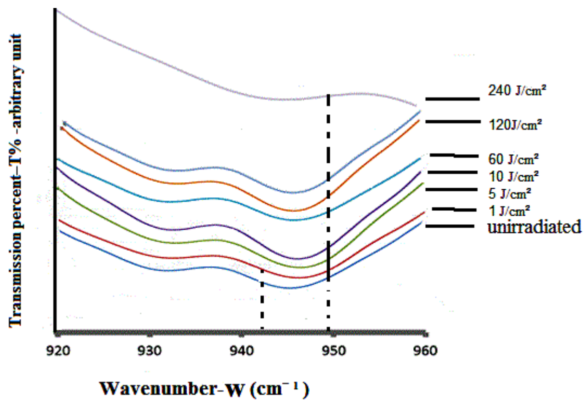

Fig.(7) Deviation of FTIR-spectrum at wavenumber- w940cm⁻¹ for uv-irradiation and UV-irradiated Lexan detector at dose range 1 J/cm² to 240 J/cm².

Fig. (7) shows the change in deviation of wavenumber-w value940 cm⁻¹ with irradiation dose from 1 J/cm² to 240 J/cm².And this deviation may be as a result formation of phenoxy radical and phenyl radical [13].

Fig. (8) shows the polynomial relationship between the UV-irradiation dose and the deviation in wavenumber–w at940 cm⁻¹ and the UV- radiation dose from above dose range.

These behavior of determine between radiation dose and wavenumber-w by following equation.

$$D\ (J/cm^2) = 1.9w^4 - 7.8\times10^3w^3 + 1\times10^7w^2 - 7\times10^9w + 2\times10^{12} \quad ......(3)$$

where D (J/cm²): UV- irradiation dose, w: wavenumber cm⁻¹.

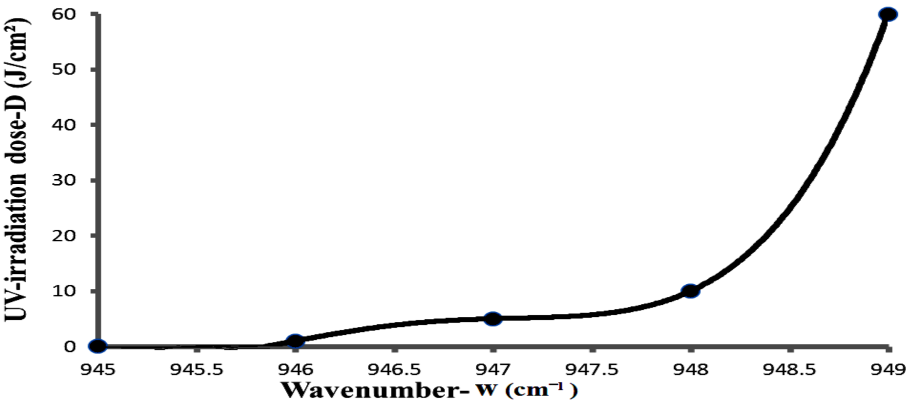

Fig.(8) Behavior of FTIR-spectrum deviation at wavenumber-w 940cm^{-1} for Lexan vs. UV-irradiation dose range from 1 J/cm² to 240 J/cm².

Table (1)
Equations of UV-radiation doseassessment for Lexan detector by measuring of wavelength at 300 nm, 304 nm and wavenumber-w at 940 cm^{-1} by using of UV-visible and FTIR spectroscopytechniques respectively.

Technique	*Equations*	*NO.*		
UV-visible	$D(J/cm^2) = 1\times10^4A^2 - 1\times10^4A + 5.7\times10^3$	1	300	**Wavelength (nm)**
	$D\ (J/cm^2) = 9.2\times10^3A^2 - 1\times10^4A + 4.7\times10^3$	2	305	
FTIR	$D\ (J/cm^2) = 1.9w^4 - 7.8\times10^3w^3 + 1\times10^7w^2 - 7\times10^9w + 2\times10^{12}$	3	940	**wavenumber-w (cm^{-1})**

Table (1) represents equation of UV-radiation by measuring of wavelength at300 nm, 304 nm and wave number-w at 940 cm^{-1} by using of UV-visible and FTIR spectroscopy respectively technique. From this Table may be use content the UV-radiation dose (J/cm²) by uses Equation (1) and Equation (2) after measuring the wavelength at 300 nm and 305 nm respectively. Also, content the UV-radiation dose (J/cm²) by uses Equation(3) after measuring the wave number-w at 940cm-^{1}. This study also used from determined the UV-radiation dose for the medical and environmental fields

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الخلاصة

في هذا العمل تم دراسة تأثير الأشعة الفوق البنفسجية على الكاشف Lexan الذي سمكه 175 µm عند مدى الجرع من $1\ J/cm^2$ الى $360\ J/cm^2$ بطاقة 15 W وتم قياس الامتصاصية الضوئية A-باستخدام مطيافية الضوء المرئي UV-visible – وقياس النفاذية النسبية باستخدام مطيافية تحول فورير تحت الحمراء-FTIR.وتم استخراج العلاقة بين الجرعة الاشعاعية UV بوحدة (J/cm^2) وبين الامتصاصية الضوئية A- عند الطول الموجي 300nm و 305 nm وبين العدد الموجي $940\ cm^{-1}$ بالإضافة الى الانحراف في العدد الموجي $940\ cm^{-1}$ تبين ان هناك امكانية استخدام الكاشف Lexan لتخمين جرع التعرض لأشعة UV في المجالات الطبية والبيئية.