



Calibration of UV-Radiation Dose with Irradiation Time for CR-39 Track Detector by Using UV-visible Spectrophotometer

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Abstract: Nuclear track detector type CR-39 irradiated by two UV-irradiation methods at wavelength 254nm. First method was PEN-ray-lamp UV-irradiation with the distance 4cm between UV source to CR-39 detector and the range of irradiation time - TD were 10,100 and 1000 s. Second method was FLX-20 transiluminator 15W energy amount with the distance 10 cm between UV source to CR-39 detector and the range of irradiation dose - DT were 2, 6, 9 and 10J/cm². The absorbance-A was determined from UV-visible spectroscopy at the measuring range from 300 – 500 nm for each method. The absorbance differences $[\Delta A]_{350}$ and $[\Delta A]_{550}$ for irradiated and un-irradiated CR-39 detector were measured between absorbance value at wavelength 350nm and 550nm respectively. In this study determined the linear relationship between the increasing of TD(s) and DT(J/cm²) with increasing of $[\Delta A]_{350}$ and $[\Delta A]_{550}$. This work obtained that FLX-20transiluminator (second method) was used as a calibration route to PEN-ray-lamp (first method) after measuring the absorbance difference $[\Delta A]_{350}$ and $[\Delta A]_{550}$ for CR-39 detector.

Keywords: Solid-State Detectors, Visible and Ultraviolet Spectra, Dosimetry, Ultraviolet Radiation Effects

1. Introduction

The effect of ultraviolet -UV radiation on the nuclear track detector type CR-39 investigated in many studies [1-3]. It was found that on extended exposure to uv- radiation, CR-39 detector slowly degrades and turns progressively yellow due to changes of its chemical and physical properties[1]. The effect of exposure to UV- radiation on CR-39 detector was also studied through determine the change in the bulk etch rate -V_b and track etch rate-V_t of CR-39 detectors at short UV wavelength[2]. Where that chemical and physical properties of nuclear track detectors NTDs [4,5] were studied by Fourier Transform Infrared - FTIR spectrometry , thermal properties were also investigated , X-ray photoelectron spectroscopy – XPS , corresponding nano-mechanical and uv-visible spectrometry [1, 3]. There was relation between the changes in the chemical, physical and mechanical

properties of CR-39 detectors under UV irradiation with the corresponding photo -degradation mechanisms in order to explain the variation of the etching behavior of CR-39 detectors in NaOH/H₂O [2].

Also Tse, K.C.C., et. al. (2008) provide the effects of UV irradiation type UVC exposure on the track etch rate-V_t and the detector sensitivity-V of CR-39 SSNTDs, and take into account the investigated through the diameters and depths of alpha-particle tracks [6]. The formation of photo-stabilizers was studied by using of uv-visible spectroscopy after UV - irradiation to the nuclear track detector type Lexan polycarbonate [7]. UV-visible spectroscopy was used to determine the absorption different at limit wavelength for analyses the shift of the absorption edge from the ultraviolet region towards the visible light region [1].

CR-39 detector used as UV- dosimeter [8] by using three techniques , Alpha tracks diameters and tracks densities , FTIR spectrometry and uv-visible spectrometry [9] . There

was many UV-radiation dosimeter technique as a erythemally weighted irradiances derived from polysulphone - PS and electronic ultraviolet - EUV dosimeters which compared with measurements obtained using a reference spectro-radiometer [10].

Where Nagpal , J. S. (1998) [2] provide the integrating type personal UVR as UV - dosimeters which having response matching with the erythema action curve [2] . UV - radiation dosimetry was working by using of thermoluminescent phosphors-TL through response of most of the phosphors which depend on the radiant flux in unit ($\mu\text{W}\cdot\text{cm}^{-2}$) [2] . Gunther Seckmeyer et . al. (2011) [10] was calibrating of UV-sensors by direct comparison to a reference instrument leads to reliable results by using of uv-visible spectrometry technique. In this study well be used UV-visible spectrometry technique to calibration of UV-radiation dose at the wavelength 254 nm for CR-39 detector from two irradiation method of UV-radiation .

2. Experimental Procedure

CR-39 is type of organic solid state nuclear track detector in the form of sheets with thickness 1200 μm , obtained from TASTRAK (Pershore Moulding , Track Analysis System Ltd . , UK) , molecular weight 274 a.m.u. , density 1.32 g/cm^3 . These sheets were cut into small pieces each with 2cm \times 2cm. CR-39 detector was irradiated by two ultraviolet radiation method at wavelength 254nm .

First method PEN-ray-lamp model F S / Shirophpto Industrial Ltd. Japan with 4cm distance from CR-39 detector to ultraviolet source , and second method was FLX-20 model FLUO-LINK FLX system from transilluminator, power 15W with 10cm distance from CR-39 detector to ultraviolet source . The measuring of absorbance-A was determine by using of UV-visible spectrometry technique model UV-1601 PC from SHIMADZU Company at the wavelength range 300- 550 nm .

3. Results and Discussion

UV-visible spectrum was measuring at the wavelength range 300-550 nm for CR-39 detector after UV-irradiation by first method PEN-ray-lamp with irradiation times- T_D (s) 10 s , 100 s and 1000 s comparing with un-irradiated detector as shown in (Figure – 1:a) .Where at the second method FLUO-LINK FLX system the irradiation doses-D (J/cm^2) were 2 J/cm^2 , 6 J/cm^2 , 9 J/cm^2 and 10 J/cm^2 comparing with un-irradiated detector as shown in (Figure – 1:b) .

From (figure-1:a) obtained there was decrease in absorbance -A with increase of irradiation time- T_D (s) for PEN-ray-lamp. Also, from (figure -1: b) there was decrease in absorbance -A with increase of UV-irradiation dose-D (J/cm^2) for FLUO-LINK FLX system .The values of absorbance deference $[\Delta A]$ at the wavelength 300nm and 550nm as $[\Delta A]_{350}$ and , $[\Delta A]_{550}$ were calculated by using equ. (1) and equ. (2) respectively

$$[\Delta A]_{350} = [\Delta A]_{350,\text{irr.}} - [\Delta A]_{350,\text{un-irr.}} \quad (1)$$

$$[\Delta A]_{550} = [\Delta A]_{550,\text{irr.}} - [\Delta A]_{550,\text{un-irr.}} \quad (2)$$

Where $[\Delta A]_{350,\text{irr.}}$, $[\Delta A]_{350,\text{un-irr.}}$: absorbance deference at 350nm for irradiated and un-irradiated respectively by UV-radiation

$[\Delta A]_{550,\text{irr.}}$, $[\Delta A]_{550,\text{un-irr.}}$: absorbance deference at 550 nm irradiated and un-irradiated respectively by UV- radiation.

The values of $[\Delta A]_{350}$ and $[\Delta A]_{550}$ which determine by PEN-ray-lamp method were increase with increase of UV-irradiation time- T_D (s) at the wavelength 350nm and 550 nm as shown in (figure-2 :a) and (figure-2:b) respectively .

The equations which reflect the relation between $[\Delta A]_{350}$, $[\Delta A]_{550}$ and UV-irradiation time - T_D (s) to PEN-ray-lamp method were calculated from (Figure-2:a) and (Figure-2: b) by equ. (3) and equ. (4) respectively

$$\ln TD(s) = \{ [\Delta A]_{350} - 0.04 \} / 0.024 \quad (3)$$

$$\ln TD(s) = \{ [\Delta A]_{550} - 0.03 \} / 0.030 \quad (4)$$

FLX-20 transilluminator The values of $[\Delta A]_{350}$ and $[\Delta A]_{550}$ which calculated by PEN-ray-lamp method were also increase with increase of UV-irradiation dose (J / cm^2) at the wavelength 350nm and 550nm as shown in (figure-3:a) and (figure-3 :b) respectively .

The equations which reflect the relation between $[\Delta A]_{350}$, $[\Delta A]_{550}$ and UV-irradiation dose - D(J/cm^2) to FLX-20 transilluminator were calculated from (Figure– 3 : a) and (Figure - 3: b) by equ. (5) and equ. (6) respectively.

$$D(\text{J}/\text{cm}^2) = \{ [\Delta A]_{350} - 0.103 \} / 0.009 \quad (5)$$

$$D(\text{J}/\text{cm}^2) = \{ [\Delta A]_{550} - 0.0095 \} / 0.007 \quad (6)$$

From (Figure –2) and (Figure –3) show there were linear relation ship for two irradiated methods between $[\Delta A]_{350}$, $[\Delta A]_{550}$ with UV -irradiation time - T_D (s) and UV-irradiation dose (J/cm^2) .

Table-1 obtained the equations which calculated from above linear relations ship for two uv-irradiated methods. These relations may be used as a conversion equations of UV - irradiation time - T_D (s) and UV-irradiation dose D (J/cm^2) .

These equations which obtained in the (table -1) may be used directly calculate the uv-irradiation dose in unit (J / cm^2) for PEN-ray-lamp by measuring the values of $[\Delta A]_{350}$ and $[\Delta A]_{550}$, which equivalent to these values in FLX-20 transilluminator . The relation of uv-radiation dose with value of absorbance-A in uv-visible spectrum was also consider through measuring the optical band gap after irradiation due to chain scission in the nuclear track detector type Lexan polycarbonate [11] . The change in absorbance after uv-irradiation depend on the energy transfer to CR-39 detectors by uv-irradiation leads to excitation and ionization of the molecular chains , hence to radical formation, main chain scission , and also to cross-linking of polymeric chains [1] .

This study open field to use CR-39 nuclear track detector after determination the absorbance-A at the wavelength 350nm and 550 nm as UV -radiation dosimeter in many

fields such as an environmental solar ultraviolet radiation measurements, dosimeter [12] and industrial or ultraviolet laboratory

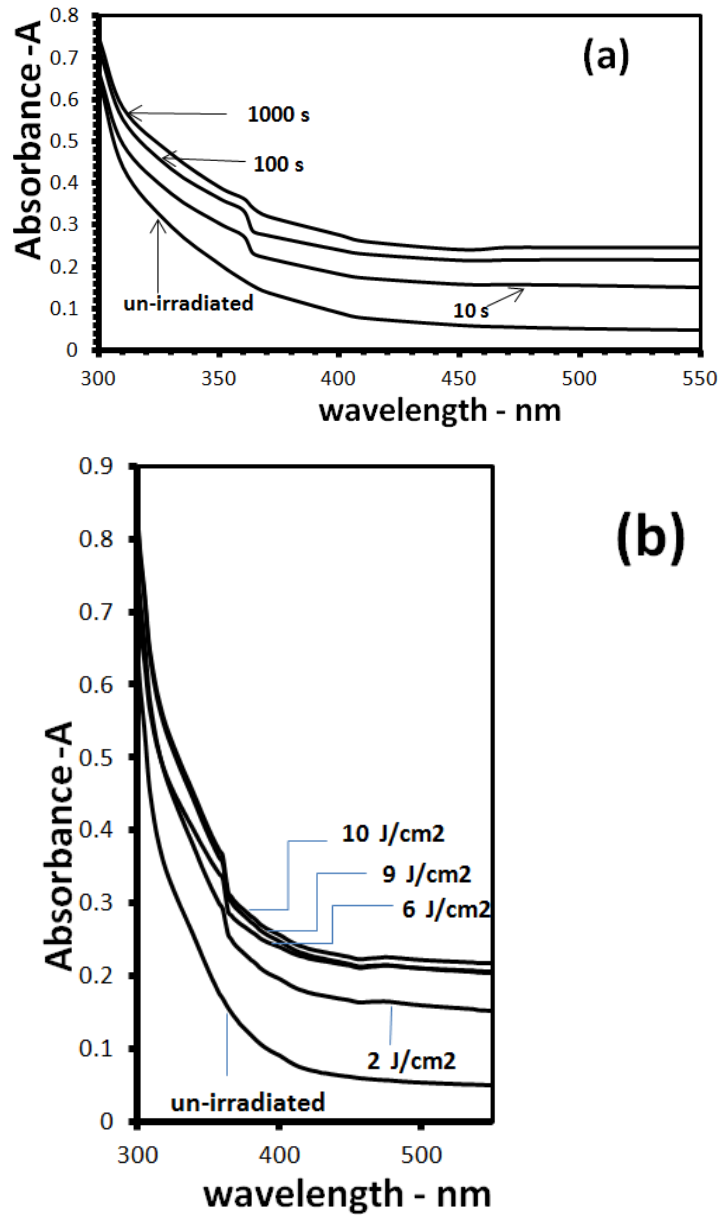
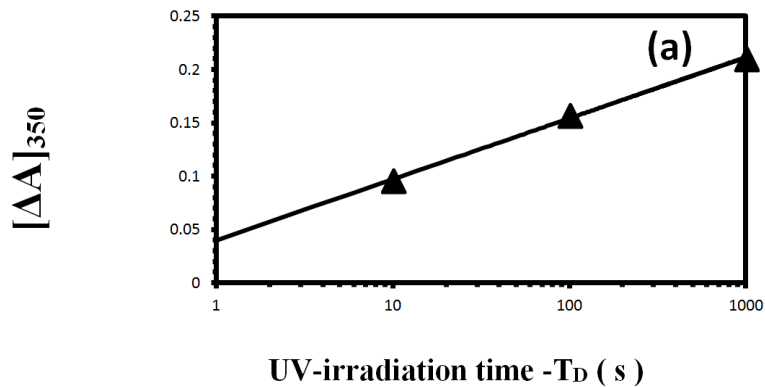


Figure 1. UV-visible spectrum at the range 300-550 nm for CR-39 detector after UV-irradiated by following irradiation method. (a) PEN-ray-lamp UV-source with irradiation times- T_D 10 s, 100 s and 1000 s comparing with un-irradiated detector. (b) FLX-20 transilluminator with irradiation dose 2J/cm², 6 J/cm², 9 J/cm² and 10J/cm² comparing with un-irradiated detector.



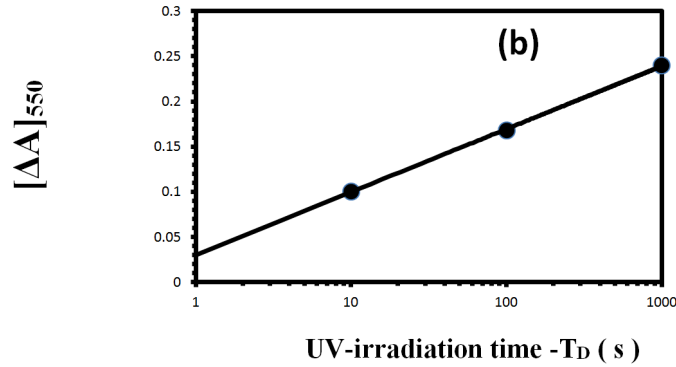


Figure2. Absorbance differences $[\Delta A]_{350}$, $[\Delta A]_{550}$ with UV-irradiation time- T_D from the irradiation method PEN-ray-lamp , (a) For $[\Delta A]_{350}$ (b) for $[\Delta A]_{550}$.

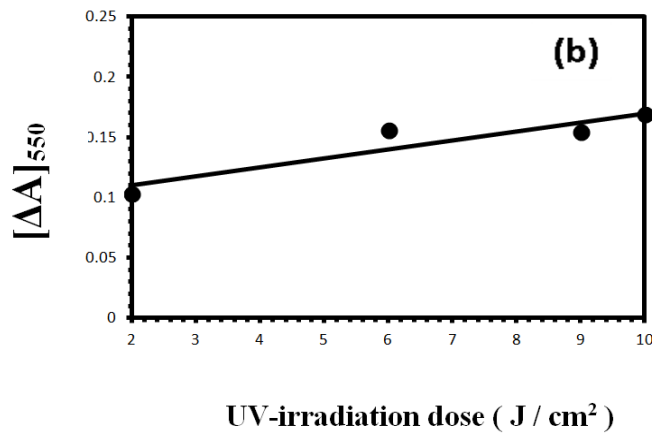
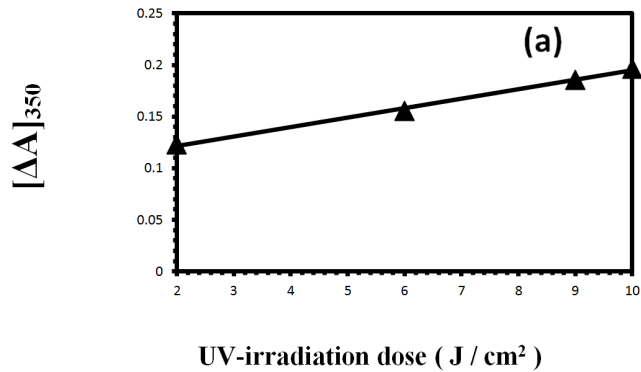


Figure3. Absorbance differences $[\Delta A]_{350}$, $[\Delta A]_{550}$ with UV-irradiation dose (J/cm^2) from the irradiation method FLX-20 transiluminator (a)For $[\Delta A]_{350}$, (b) for $[\Delta A]_{550}$.

Table 1. Conversion equations of UV-irradiation time - T_D (S) and UV-irradiation dose D (J/cm^2) with $[\Delta A]_{350}$ and $[\Delta A]_{550}$ for PEN-ray-Lamp and FLX-20 transiluminator UV -irradiation methods respectively .

[ΔA]	UV-irradiation method	
	PEN-ray-lamp	FLX-20 transiluminator
$[\Delta A]_{350}$	$\ln T_D(s) = \{ [\Delta A]_{350} - 0.04 \} / 0.024$	$D (J/cm^2) = \{ [\Delta A]_{350} - 0.103 \} / 0.009$
$[\Delta A]_{550}$	$\ln T_D(s) = \{ [\Delta A]_{550} - 0.03 \} / 0.030$	$D (J/cm^2) = \{ [\Delta A]_{550} - 0.0095 \} / 0.007$

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