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A Study of the Optical Characteristics of CR-39 Nuclear Track Detector Using Ultraviolet Irradiation

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ABSTRACT

The effect of the UV radiation is studied to investigate the optical properties of CR-39 polymer. The measurements of FTIR spectroscopy show maintenance of the main vibratory band resulting from the irradiation times. The optical absorption spectrum of UV / VS indicates a main alteration in the optical energy gap with irradiation times. From the results, it was found that increasing the irradiation time of CR-39 by UV- lamp leads to an increase in the sensitivity of the detector and improvement of its properties and thus achieve safe use of these detctors. FTIR spectra shows the conservation of the distinctive spectral peaks related to the monomer of polymer before and after exposure to different intensities of UV-lamp. From this results, the CR-39 detector ultraviolet irradiated were conformed to be very sensitive to UV radiation.

1. INTRODUCTION

Nuclear track detectors such as CR-39 is used in various fields such as the manufacture the lenses of glasses and in building as wall. CR-39 detector can also be used to measure radon and neutron dosages [1]. During their use, nuclear path detectors can be detected at temperatures above ambient levels. CR-39 is the nuclear path detector could maintain the dosage information under different environmental conditions. Ultraviolet rays have a very large effect on detector sensitivity. UV lamp exposure increases the volume, total volume and drilling rate of the average path at peaks corresponding to 254 and 350 nm lines, while decreasing at 300 nm. [2].

The influence of UV- rays- on CR-39 detector has been examined in several works. The CR-39 detector gradually decomposes due to changes in its chemical and physical characteristics and gradually turns yellow when exposed to UV–rays[3]. UV radiation and photons having more energy can have important and profound effects on the properties of path detectors behind electrons or other particles that may not be able to be monitored. The effects detected are restricted to plastics, unless the doses are very high [4]. By breaking chemical bonds in polymers, the molecular chains can be separated, which can occur with less energy transfer than usually required for ionization (2-3 eV vs. 10-15 eV) [5]. UV rays are easily spread through glass and air. Ultra Violet absorption spectral range, UVB (Ultraviolet A has a longer wavelength) and UVC (Ultraviolet B has a shorter wavelength) rays travel through the air and quartz, but get absorbed in regular glass. The reason is that these wavelengths are absorbed by layer of ozone in the higher atmosphere because the solar radiation on Earth's surface is almost free of wavelengths less than 320 nanometers. Ultraviolet rays under 315 nm is absorbed primarily by the layer of skin. Ultraviolet rays with wavelengths Less than 200 nm are not simply transferred by air and are typically only found in a space [6,7].

The current work aims at studying the properties of CR-39 (structural and optical) under irradiation of ultraviolet lamp for different exposure times, because polymer detector of CR-39 is used as an UV dosimeter in several areas such as UV-Rays for solar atmospherics, industrial laboratory and UV-radiation measurements

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2. Practical Analysis

2.1. Material and irradiation

The molecular formula of CR-39 polymer is ($C_{12}H_{18}O_7$), its density is 1.32 gm.cm^{-3} and the temperature of glass transition is 85 °C. Sheet created and introduced by Track Systems Ltd. (TASL), Bristol, United Kingdom. Standard a thickness of 600 μm was reported. It was split into a size of 1.5× 1.5 cm^2. UV lamp of 50 W was used for exposure. In this study, ten samples were exposed to integrated UV lamp in the times varied from 2 to 10 hours. In the UV band, almost the visible spectrum is fully invisible and has a high impedance of corrosion. The system of irradiation contains on UV lamp (FH1200-X) of 220 W at 220V. Samples were exposed to a constant irradiation at a space of 70 cm through a collimator to the UV-lamp source.

2.2. UV/Vis Absorption

The alteration in optical absorption of virgin and CR-39 -irradiated samples were executed by Spectra of UV/vis. UV/vis Spectra was achieved by UV/Visible Double Beam spectrometer JASCO V-630.The wavelength range of JASCO technique is 200-1100 nm at an interval of 1 nm, at ambient circumstances.

2.3. FTIR- Technique

FTIR technique can be used for the clarification of functional groups in CR-39 polymer molecules. Within the range of 400 to 4000 cm^{-1} for wavelength and 4 cm^{-1} resolution of the Nicolet 6700 spectrometer- thermo-scientific, the spectrum of CR-39 samples was achieved. To gain the alteration in the functional groups of CR-39 polymer between the virgin and the irradiated samples with UV lamp these spectra was analyzed.

3. RESULTS AND DISCUSSION

In the absorption behavior, the analysis of UV–Visible spectra was conducted for the pristine and UV-irradiated CR-39 samples through elevated to varied UV lamp doses. The effect of UV wavelength (200-400nm) on CR-39 samples are obviously appeared by absorption rate in this range of UV-wavelength as shown in Fig.(1), and the absorption rates increased gradually by increasing the irradiation time as 10h > 8h > 6h > 4h >2h >0h. The peak of UV–Visible deviates from the UV area to the visible area, which is heading to the greater wavelength, for the irradiated samples. This clarified that a significant decrease occurred in optical band gap energy after UV- irradiation, and the expanding of the absorption peak through increasing the exposure time[8].

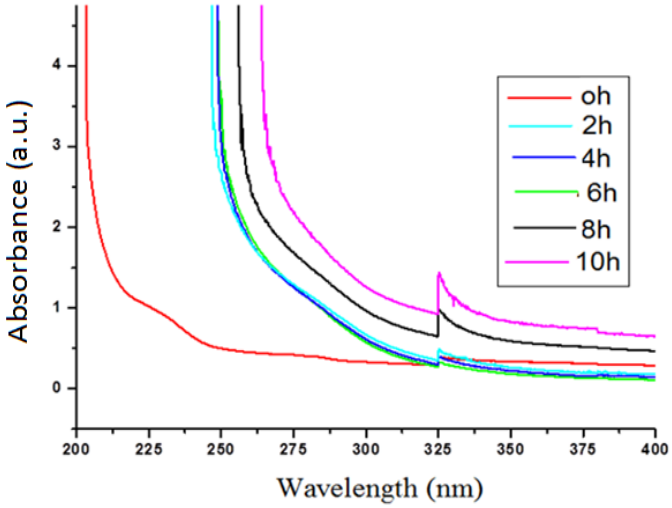

Fig. (1): Absorption process and wavelength for the CR-39 detectors.

Fig. (2) displays the manners of absorption process as a function of the irradiation time on the absorbance spectrum for all the investigated samples at the wavelength varied from 200nm to 400nm. It can be observed from this Figure that there is a linear relationship between the absorption rate and the irradiation time which has a strong coefficient (R^2 =0.78) and that with increasing the irradiation time, the absorption rate increases. This positive relationship demonstrates the effects of radiation on polymeric substances, and this linear relationship represents the probability that alpha particle energy can be measured using CR-39 polymer track detectors using absorbance variance only within this range [9, 10].

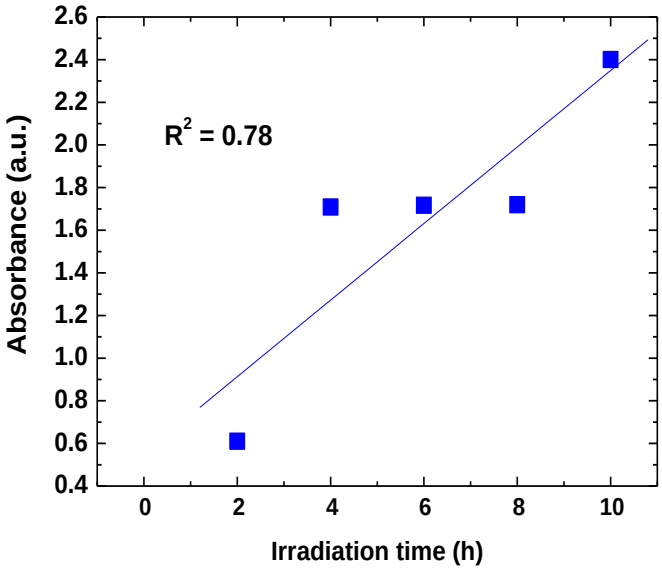

Fig. (2): Absorption rate as function of the UV irradiation time.

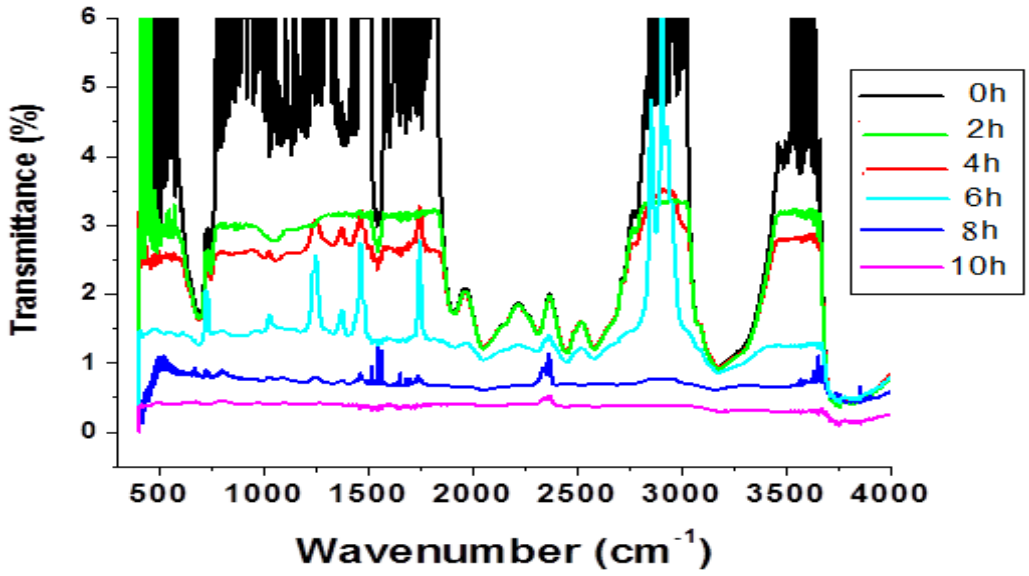

Fig. (3) FTIR spectra of pristine and irradiated CR-39 samples.

Fig.(3) shows the FTIR spectra which indicates the conservation of the distinctive spectral peaks related to the monomer of polymer before and after exposing to different intensities of UV lamp. Fig. (3) shows the FTIR spectrum of CR-39 in its wavenumber (cm^{-1}) and the related significance of the functional groups related to pristine CR-39 sample. It is obvious that the main distinctive peaks of the pristine sample related to obvious functional groups. The registered corresponding band peaks of the sample are at 657 cm^{-1} , 1462 cm^{-1}, 1773 cm^{-1}, 2348 cm^{-1}, ,2849 cm^{-1}, 3282 cm^{-1} and 3542 cm^{-1} which are relevant to the absorption band of CO_2, bending vibration related to CH_3 and to CH2 small bands, C −O stretch, absorption band of CO_2, C− H symmetric stretching of $-CH_2-$, alkynes end group (R − C≡C − H) and OH group and / or adsorbed water respectively [11,12]. The bands intensity have been shown to decrease as the irradiation phase increases, which points to the decrease in the unsaturated behavior of polymers. The irradiation time ions in the bands related to 8 h, and 10 h were found to disappear with increasing radiation dose, this decrease in the intensity of C=O band has also been observed [11]. The decrease in peak intensity may be related to the splitting of the carbonate bond chain producing CO_2 and carboxylic acids [13, 14, 15]. The relationship between the cleavage of carbonate and the removal of H from the polymer structure is related to the decrease in intensity that results in the formation of CO_2 and-OH [16].

CONCLUSION

Ultraviolet irradiation investigation of the absorption process is a significant mechanism that relates to the structural variations within the polymer material. The UV/vis optical absorption spectrum induces a progressive increase in the absorption rate by increasing the irradiation time. FTIR spectra shows the conservation of the distinctive spectral peaks related to the polymer monomer before and after exposure to different intensities of UV lamp. These results indicate that the ultraviolet irradiated CR-39 detectors were conformed to be very sensitive to UV radiation.

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