Spectrophotometrically Analysis of PMMA as a low – Doses Dosimeter

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ABSTRACT:

Polymethylmethacrylate film (PMMA) of thickness 75 μm was evaluated Spectrophotometrically for using it as a low-doses gamma radiation dosimeter. The doses were examined in the range 0.1 mrad-10 krad. Within an absorption band of 200-400 nm, the irradiated films showed an increase in the absorption intensity with increasing the absorbed doses. Calibration curves for the changes in the absorption differences were obtained at 218, 301, and 343 nm. At 218 nm the response for the absorbed doses is a linear in the range 10 mrad- 10 krad. Hence it is recommended to be adopted as an environmental low doses dosimeter.

الخلاصة:

تم فحص إمكانية استخدام فلم PMMA بسمك 75μm كمقياس للجرع الإشعاعية الواطئةلأشعة كاما طيفيا، تقع الجرع ضمن المدى (0.1mrad-10krad) ،وضمن الطول الموجي الذي يقع ضمن المدى(200-400nm). أظهرت الأفلام المشعة زيادة في شدة الامتصاصية بازدياد الجرع الممتصة. رسمت منحنيات المعايرة للتغيرات في الفرق في الامتصاصية عند الأطوال الموجية (218,301,343nm). وجد بأنه عند الطول الموجي (218nm) كانت الاستجابة للجرع خطية عند المدى (10mrad-10krad)، لذا ينصح باعتماده كمقياس للجرع الإشعاعية الواطئة.

INTRODUCTION:

The increasing interest in plastic films used for dosimetric purposes is closely related to the increase in large radiation sources of the type used in radiation processing of various materials [1]. Several polymeric materials in form of thin strips have successfully been used as routine dosimeter. One of the most commonly used polymeric materials as a radiation dosimeter is the family of acrylic plastic such as dyed or undyed poly (methylmethacrylate). When irradiated by ionizing radiation, degradation products are formed and electron and hole trapping takes place causing changes in optical absorbencies. The radiation induced absorption changes in these plastics are generally proportional to the absorbed dose [2]. It can be read in conventional UV/VIS spectrophotometer [3]. The PMMA has useful properties for example, rigidity and excellent optical density [4]. In the radiation processing of materials by ionizing radiation (X-ray, gamma ray, and electron beams), several plastic types of material and commonly used as routine dosimeter for determine absorbed doses. Upon irradiation the systems undergo a fairly reproducible and permanent change in the near ultraviolet and visible absorption spectrum. Characteristic curves are generated by means of spectrophotometer readings of the change of optical density at selected wave lengths (ΔA_{λ}) as a function of absorbed dose (D_i) in the material interested (i)[5].

EXPERMENTAL RESULTS:

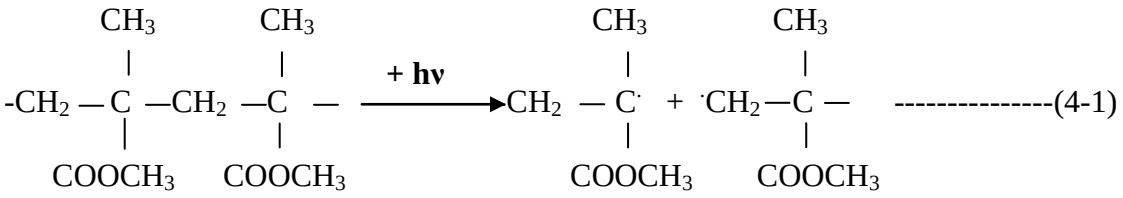
The prepared film was irradiated with aid artificial vacuum system. To investigate the effect of reducing air pressure, the chamber was evacuated to 10^{-3}torr. Using ^{60}Co source performed the irradiation. The dose range was (0.1mrad-10krad).The films were irradiated as 1cm X 2cm strips of thickness(75μm). The spectra of films were determined using a UV/VIS spectrophotometer which operating in the wavelength range of 200 to 1100nm.

RESULTS AND DISCUSSION:

Representation of ultraviolet and visible spectroscopy for pure PMMA before and

after irradiation with ^{60}Co γ-ray for doses within (0.0975mrad-9.75krad) range is shown in (Fig.1). The figure reveals a strong absorption probability below λ=220nm, and sudden decrease was observed above this limit; the absorption tends to lower than 11% at λ=267nm. In the visible region, PMMA is transparent, by Osaka and Fukuda a similar trend have been observed [6]. During irradiation, photolysis of PMMA is occurred which results in chain scission of the polymer chain backbone by a radical process. Three major reactions are reported to occur at the same time:

i) Random hemolytic scission of main-chain carbon-carbon bonds [6,7]:



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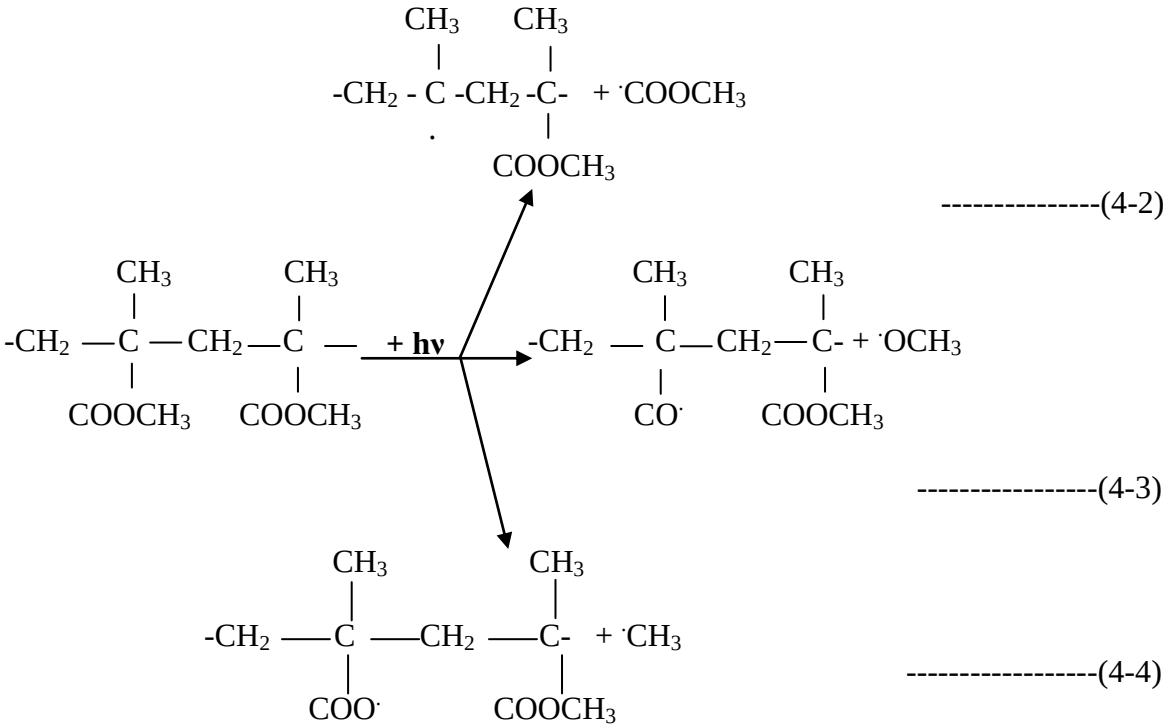
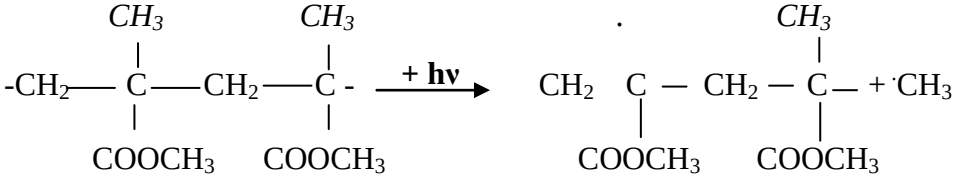
ii)Photolysis of the ester side-groups:



<u>iii) Photo-dissociation of methyl side groups:</u>



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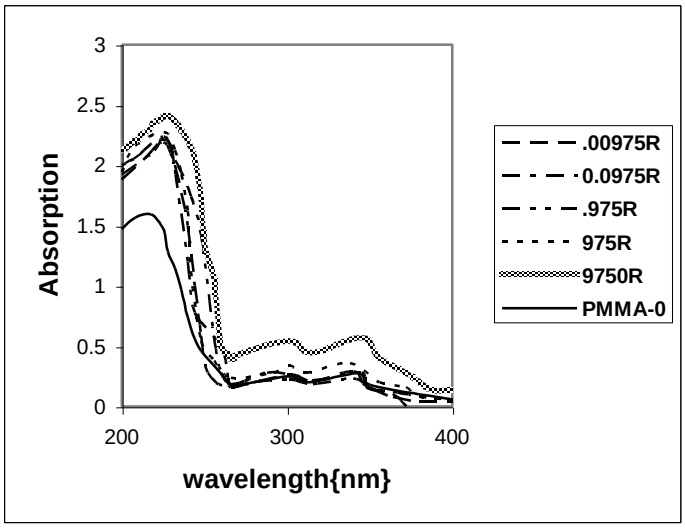
The main products of photo degradation of PMMA in vacuum are methyl formation, methanol, and methyl methacrylate with quantum yields of 0.14,0.48,0.20 respectively, and in air

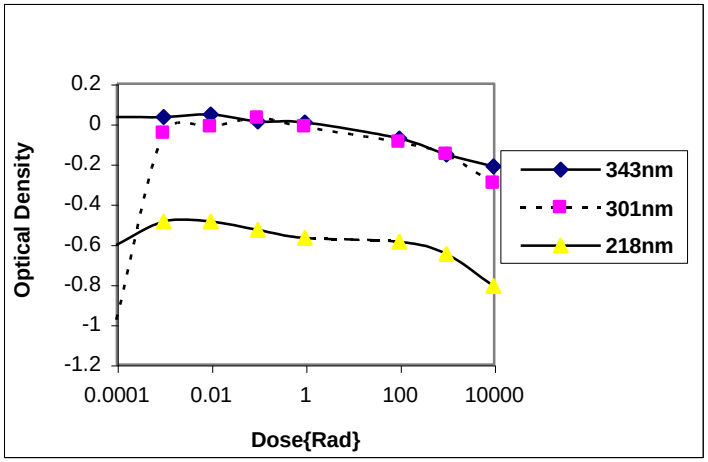
methane, hydrogen, carbon monoxide, and carbon dioxide are formed in addition.

Samples of PMMA irradiated with ultraviolet and γ-ray are almost identical. This indicates that the same types of free radicals are formed during both kinds of irradiation [7,8]. Therefore when PMMA was irradiated with γ-ray, degradation products are formed and electron and hole trapping take place causing changes in the optical absorbance (Fig. 1), which in agreement with Khan, and Ahmad results [2]. Upon irradiation, the systems undergo a fairly change in the near ultraviolet spectrum [4]. The irradiated PMMA exhibits a marked absorption below λ=220nm; other peaks may shift according to the dose [9]. There was systematic increasing in optical absorbance with doses (9.75mrad-9.75krad) range at wavelengths 218, 301, and 345nm (Fig.1).

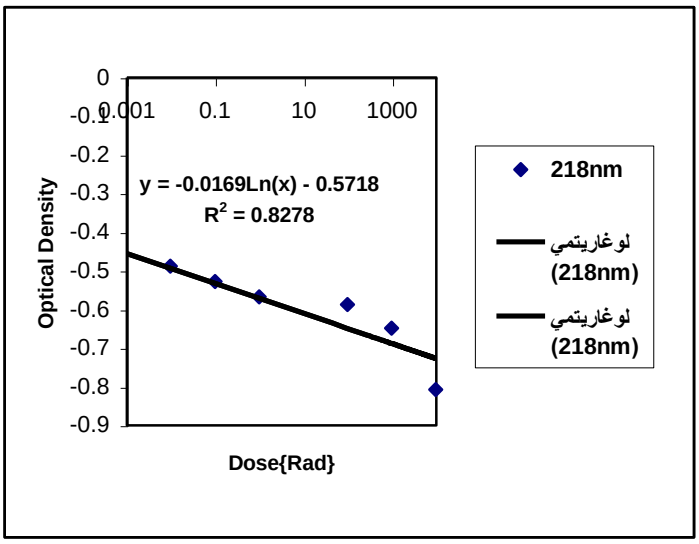
The absorption spectrum shows induced absorption changes in the (200-400 nm) range (Fig.1). There is increasing in optical absorption that can be attributed to degradation products, which are formed, electron and hole trapping taken place-causing changes in optical absorption. Calibration curves were drawn at 218,301,and 343nm(Fig.2). At 218 where is an increase in radiation-induced absorption, the optical density difference as a function of absorbed dose is linear from 10 mrad-10 krad(Fig.3).



(Figure.1): UV Absorption spectroscopy as a function to the wavelength in PMMA.



(Figure.2):Optical density as a function to the doses in PMMA.



(Figure.3):Optical density as a function to the doses in PMMA.

CONCLUSION:

75µm thick PMMA can be used as a radiation dosimeter for gamma ray in the dose range of 10mrad-10krad. This dose range is important for using as an environmental and personal dosimeter.

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