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The effect of gamma-irradiation on absorption spectrum of fluorescein dye

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ABSTRACT

In this study, the fluorescein dye was dissolved in the solvent Dimethyl Form amide (DMF). Weighed equivalent to 0.0664, 0.0996 and 0.132 gm from the material. Using 5mM of solvent, each weight of the substance was dissolved separately to obtain the concentration 60 and 80 mM respectively. The effects of both concentration and gamma radiation on optical spectrum of all samples were investigated at room temperature. After irradiation and within the different concentration percentage at fix dose (4.7 KGy), where the results showed increase absorbance with increase concentration (40, 60 and 80 mM). Also, it is found that the decrease absorbance spectrums at wavelength 460 and 487 nm with increase dose and the good stability absorbance spectrum with time. Because of this, the structures in question are regarded as an efficient material for carrying out real-time gamma radiation dosimetry at ambient temperature.

1. Introduction

Radiation can cause deleterious effect in living systems especially gamma-ray which is considered one of the most dangerous cosmic rays that exist in the cosmic space, which causes many skin diseases because they can penetrate the skin and damage the cells inside. Ionization of atoms may be accomplished directly by photons (gamma rays and x-rays) through the photoelectric effect and the compton effect, both of which result in the production of relatively energetic electrons. Because the secondary electron is going to go on to trigger several ionization events, the secondary (indirect) ionization is far more important than the direct kind. No matter what we do, radioactivity will always be a part of our lives, regardless of whether or not we are aware of it. Radiation cannot be detected by any of the human sense organs; it cannot be seen, nor can it be heard; it cannot be smelt or tasted; it cannot be detected by the skin; and it does not have any effect on the vestibular system. But it is something that more or less surrounds us everywhere: Background natural radiation, which is always present, is conditioned by cosmic radiation and by pure earth radiation; walls and dinnerware in the house may

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release radiation; radiation is always present in foodstuffs. It is therefore essential to detect it, in order to take preventive measures for human safety. Techniques for gamma-ray spectroscopy are constantly advancing as a result of tremendous advancements in the invention and manufacture of faster and greater light output scintillation materials for the detection of gamma rays [1-3]. There are several methods for detecting nuclear radiation, including gas ionization Detectors, scintillation detectors, nuclear trace detectors, act. And each of these method works according to its own principle. Fluorescein is dye and an organic compound belonging to the Xanthene's family. It easily dissolves in water and alcohol [1]. It appears as a yellow solution when dissolved in dilute basic solutions, and is soluble in highly dilute acids. It shows a strong yellow-green fluorescence when exposed to light. The chemical formula for Fluorescein dye is $C_{20}H_{12}O_5$, its density is 1.602*gm/cm*^{3}, and an molecular weight of 332.311 *gm/mol*, has a melting point 314-316 ^0C [1-5]. Since its discovery in the last century, the fluorescein dye has proved an effective role in many scientific, military, artistic and medical applications. Due to its highly fluorescent and inactive, light weight, Inexpensive, and the easy preparation of equipment prepared at the Micro level. In addition to its high absorption coefficient and easily deal with it. In World War II, The pilots have brought ampoule from the dye in the sea, so that it is easily seen from the sky [5,7]. The fluorescein dye is the basic tool for diagnosis and photography of blood vessels, and Retina Disorders in ophthalmology. It is also used to detect the spinal liquid leakage in nerve surgery. It is a security medicine for man. The fluorescein dye is improved Micro-evaluation performance. And as it is features with maximum absorption at 494nm and maximum emission at 512nm, the fluorescein dye is used in the industry of the light receptors (photoreceptors). Radiation isn't used as much as it used to be because it can change the molecular weight or break down some major parts. For example, polymers, hydrogels, and packaging materials that are exposed to up to 10 KGy of gamma irradiation can have their molecular weight change slightly or break down[8,9]. Chemical dosimeters are materials that were manufactured from radiation-sensitive compounds. When exposed to radiation, these materials undergo changes in their physical or chemical characteristics that are proportional to the amount of radiation that they have absorbed[10,11]

In the present study, the gamma-ray response capabilities of Fluorescein dye at 460 nm and 487 nm for different dose to be used as a gamma ray detector and a radiation dosimeter. This dye has been used for its abundance, cheapness, and its possible use as a dosimeter, similar to the methylene.

2. Material and methods

2.1 Sample preparation

Preparation of thin films from the fluorescein dye by casting method. The fluorescein dye was dissolved in the solvent Dimethyl Formamide (DMF). Weighed equivalent to 0.0664, 0.0996 and 0.132 gm from the material. Using 5mM of solvent, each weight of the substance was dissolved separately to obtain the concentration 60 and 80 mM respectively. Where the relationship below was used to determine the weight of the substance to be dissolved to obtain the required standard:

$$M = \frac{W_t}{M_{wt}} \times \frac{1000}{V^*} \qquad 1$$

M :Molar concentration (mol/L) ,W_t :Weight of the dye dissolved in the solution (gm), M_{wt} :The molecular weight of the dye (gm/mol), V^* : Solvent volume (ml). After that, the solutions are placed on the magnetic stirrer, with thermal base, for a period of 1 minute, at a temperature of 50 ºC. The needle filter was used to filter the resulting solutions and purify them of impurities. As for the host, it is prepared by dissolving 2gm of polymer Polymethyl Methacrylate (PMMA) by DMF solvent, with a volume of 30ml.Then 1ml of the dye solution for each concentration was mixed separately with 1ml of

PMMA polymer. Each of them was mixed for 10min to ensure the homogeneous mixing of the components of the dye and the host PMMA. Using a mechanical pipette, a quantity of the homogeneous solution was withdrawn and poured onto clean glass slides and leave for 48 hours for the solvent evaporation. Finally, the thickness of the sample is measured and it is equal to 0.00548 $\pm$ 0.00254 mm. A disc-type ^{137}Cs- gamma radiation in the dose range 4.7-18.8 KGy at dose rate of 0.47 Gy/min. In order to achieve electronic equilibrium during the gamma ray irradiation, a piece of Plexiglas measuring 3 millimeters in thickness was employed with each sample [12-14].

2.2 Waviness Analysis

In this particular investigation, cesium-137 acted as a gamma ray generator. The strength of Cs- 137 source was 12 curi in 1982 and the source is adjusted to provide a dose rate of approximately 100 rad / min in October 21, 1982. It has a longer Half-Life of 30.1 years, emits gamma rays at a dose rate of 48 rad/min, and emits energy with a value of 662 KV. The PMMA film was irradiated with gamma rays at the dose of 4.7 KGy, for the three concentrations. Where the polymeric films are irradiated by exposure to gamma rays in different doses at different times. After irradiation, the samples were photographed using a Lenovo USB 2.0 optical microscope with a UVC-DM500 camera so that changes in the profile of the films could be determined. The surface morphology characterization of 4.7 kGy irradiated PMMA films using Lenova optical microscope combined with texture, waviness and roughness of the entire film surface was studied in optical microscopy image analysis. The texture, waviness and roughness of the entire surface of each polymer film were analyzed in order to determine whether there were any changes on the surfaces of the films with increasing concentration. It is also possible to note that FLs:PMMA are uniformly spread throughout the substrate and that there are no cracks, defects or holes in the material. The sample that was irradiated with 4.7 kGy of gamma rays showed defects on its surface, and the color of FLs: PMMA films changed from yellow to yellow-orange as a result of radiation exposure, so there is little ripple and even roughness in addition, holes can be seen clearly appearing on the surface of the irradiated films, and they come in a variety of shapes and sizes. FLs: PMMA samples were subjected to the action of gamma irradiation, which led to the surface changes (see Fig.1) , The polymer film clearly showed some dots or small, dashed, black-colored lines indicating a chemical bleaching process on the surface. This was clearly seen when the waviness and texture of films with three different concentrations were studied. The increase in the bleaching area of the irradiated sample at a dose of 4.7 KGy of gamma is indicated by the appearance of pits represented by curves that have a large curved bottom when scanning on two dimensions and this is correlated with the appearance of a dark area on the surface of the films.

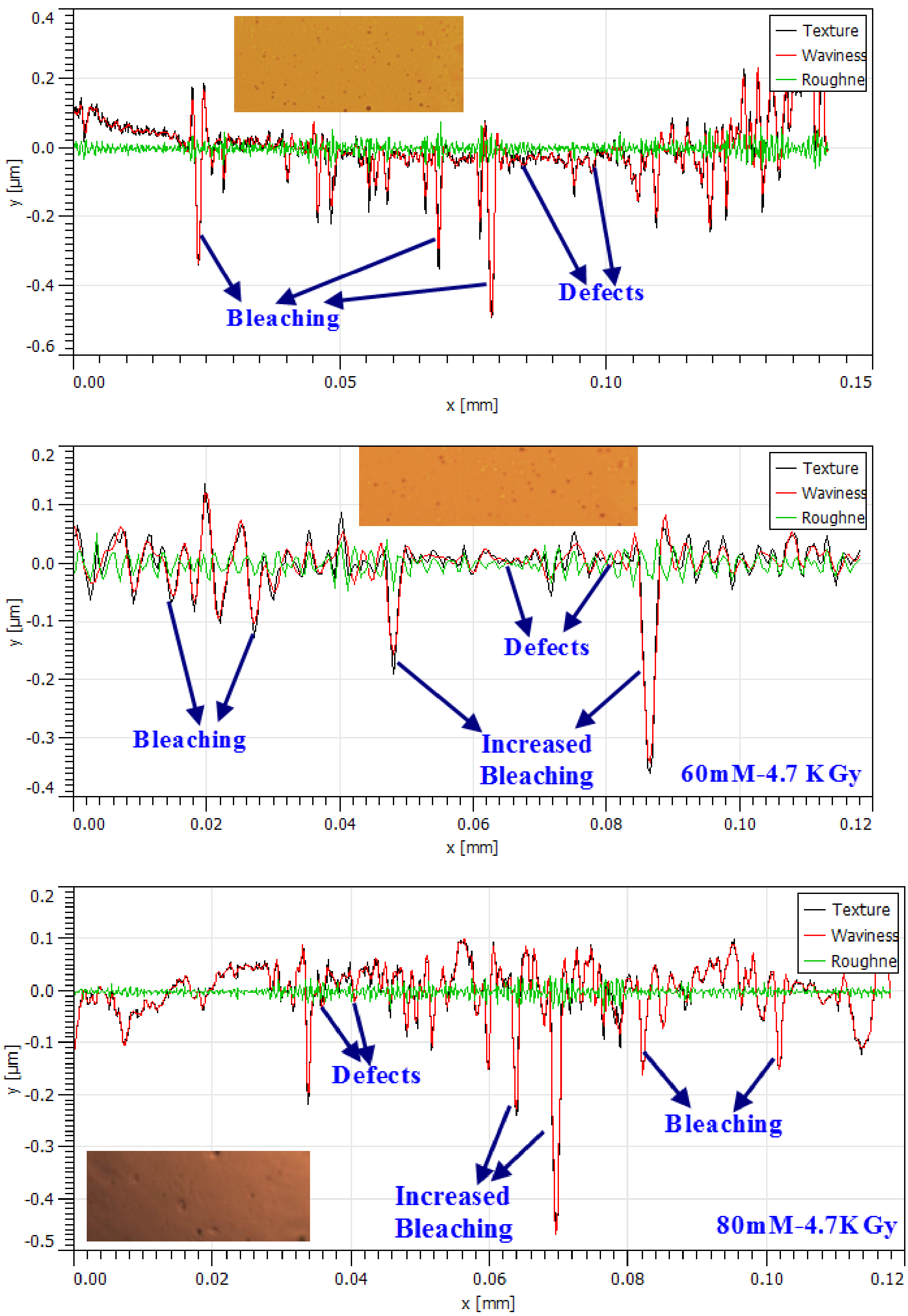

Fig. 1. Surface morphology of FLs:PMMA samples with deferent concentration shows the texture, waviness and roughen analysis of the entire surface of the films. Inset shows the optical images of the polymer film under γ- ray dose from 4.7 KGy.

2.3-Result and discussion

The advent of nuclear weapons and power sources has promoted an interest in simple, solid state detectors for high–energy radiation. More or less successful attempts have been made to exploit various coloration phenomena for this purpose. The most obvious phenomenon, the production of new absorption band, has achieved some use for the dosimetry of high doses (gamma rays) involved in somatic radiation injury and in radiation therapy the direct measurement of absorption changes has not been found useful. For this dose range the ultraviolet –excited luminescence of radiation-induced color centers (radio photoluminescence) has been found to be more suitable. Luminescence technique-either thermoluminescence or optically-stimulated luminescence are also required to measure doses radiation in course of their daily work [15]. In this research, an attempt is made to measure the response of the dye under study to gamma rays. Fig.2 shows The absorption spectrum of the fluorescein dye with different concentration, irradiated with fixed dose of gamma radiation, one week (4.7 KGy) consists of a broad band in the visible , peaking near 487 nm, and anther band to 489nm this absorption peaks is assigned to $\pi - \pi^*$ transition [16, 17]. The absorption intensity is strongly depended on concentration at 80 mM due to color change (see fig 3). Our result shows a dependence of the shifts on the absorption spectra with different dose in the direction of the large wavelength at half width of spectrums (see figs. 4, 5 and 6). This effect is not completely understood at the moment. Possible indicating the appearance of new electronic transitions. The shift on the absorption spectra at the wavelength 460 and 487 nm are linearly dependent on dose at concentration at 80 mM, as can be seen in fig 7. It is found that the decrease absorbance spectrums at wavelength 460 and 487nm with increase dose. The effect induced by the action of gamma-rays presents a good stability with time, see fig 8. In summary we have found that the Fluorescein can be used to make sample dosimeter assays with a board dose range from 0 - 18.8 KGy adequate for accidental dosemetry application.

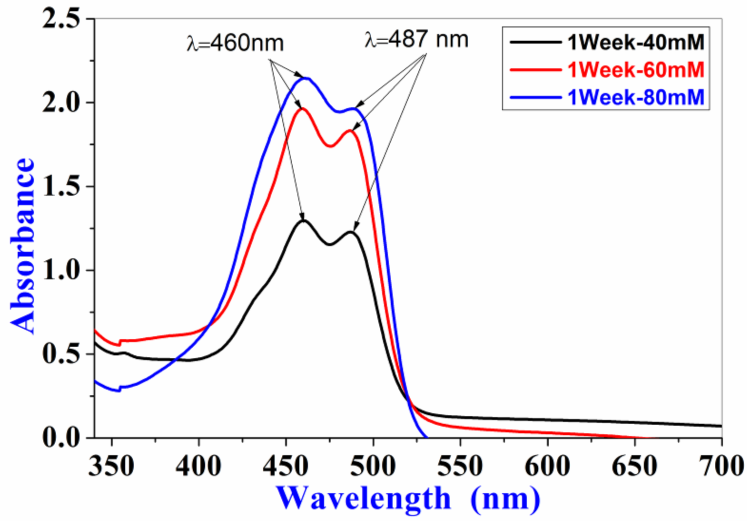

Fig. 2. Absorption spectra for FLs:PMMA films at fix dose of 4.7 KGy gamma radiation.

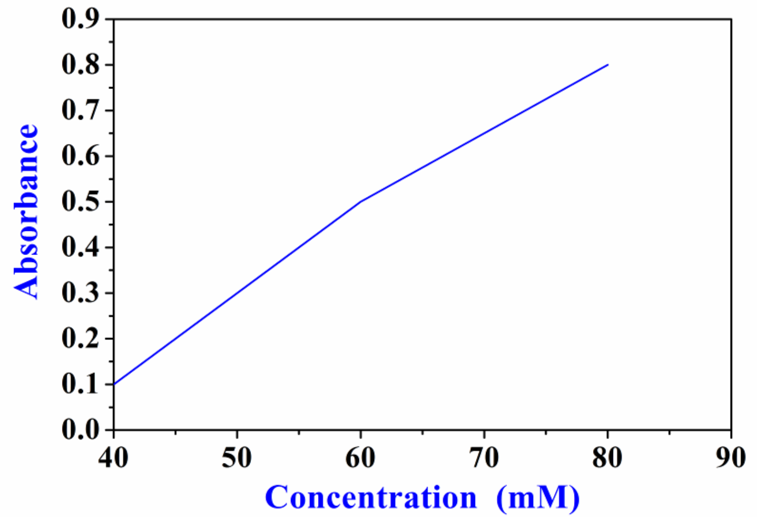

Fig. 3. Absorbance increased for increasing the concentration at fix dose 4.7 KGy

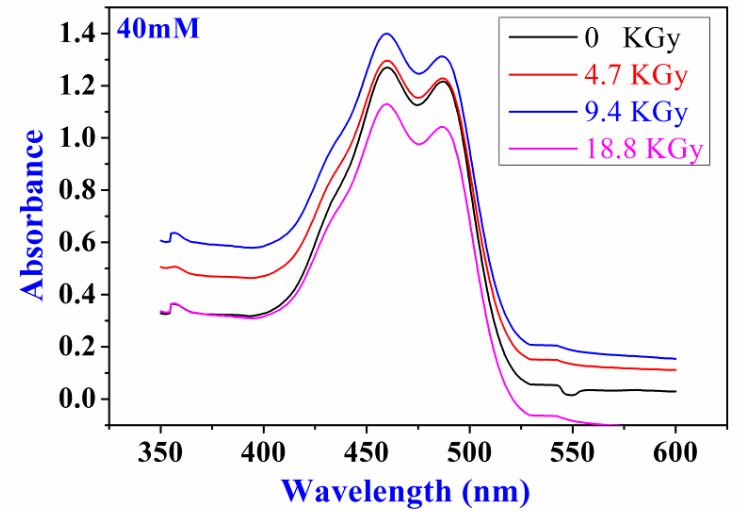

Fig. 4. Absorption spectra for polymer films of 40 mM at different dose.

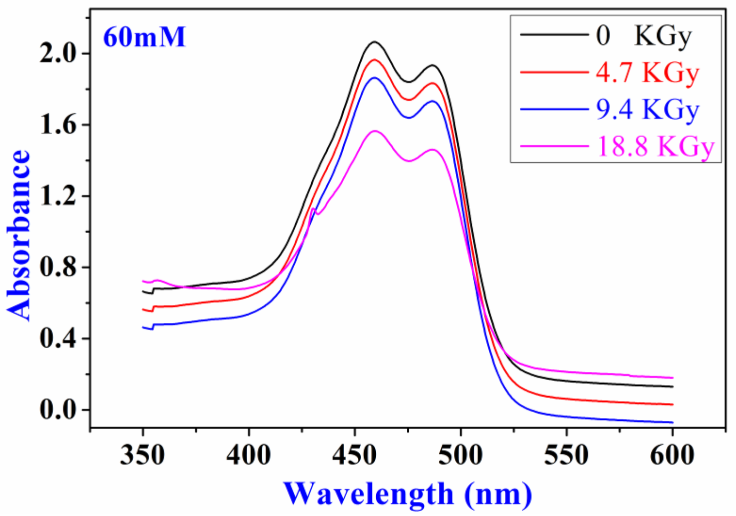

Fig.5. Absorption spectra for polymer films of 60 mM at different dose.

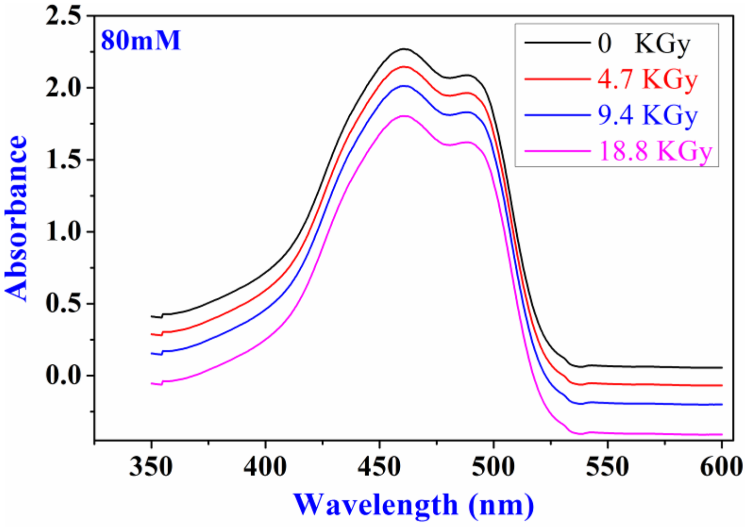

Fig. 6. Absorption spectra for polymer films of 80 mM at different dose.

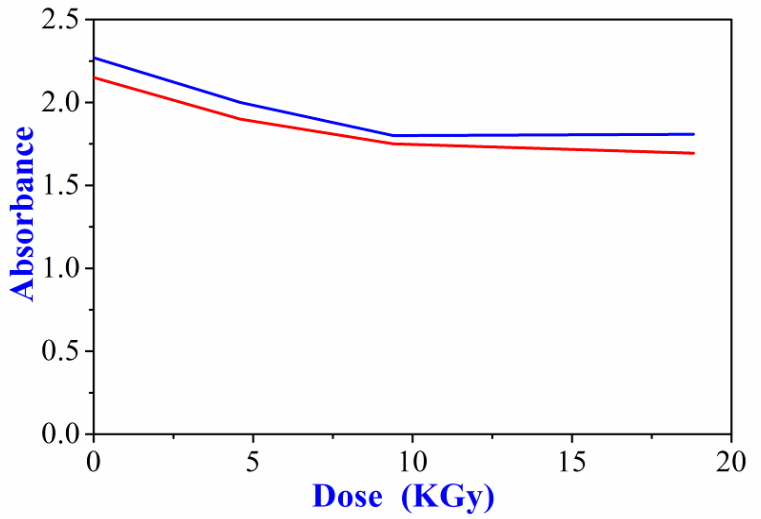

Fig. 7. Variation of absorbance with the gamma radiation dose at 460 and 470 nm.

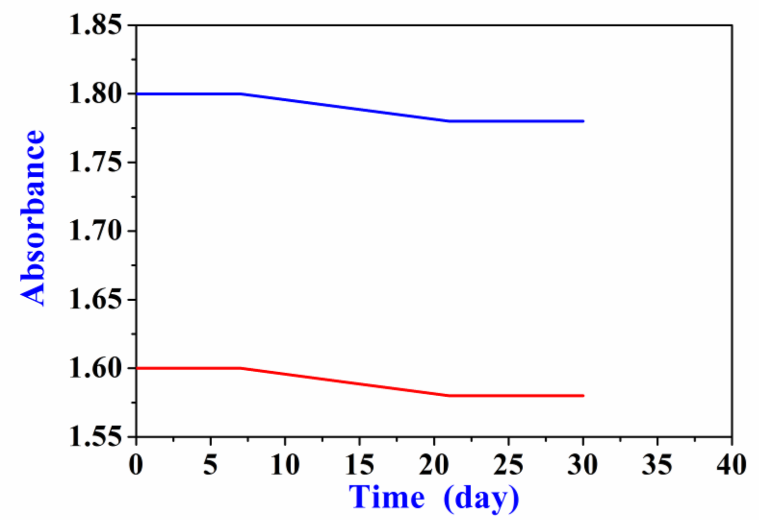

Fig. 8. Post-irradiation stability of sample to 4.7 KGy and stored at a different time for 460 and 487nm.

3. Conclusion:

In this study, the response of fluorescein to gamma rays was measured and used as radiation dosemetry. The absorption spectra of three prepared samples of fluorescein at different concentrations were measured when exposed to gamma radiation at a dose of 4.7 KGy. It was observed for concentration between 60 and 80 mol that the linearity increase of the dose response with absorbance. The effect of the action of gamma Rays induced on the fluorescein substance gives good stability over time is shown in Figure 7. In short, we found that fluorescein can be used as a dosimeter for the purpose of examining models irradiated with gamma rays with a dose range ranging from 0 to 18.8 KGy. The effect of gamma rays was obvious on the polymer films by studying the waviness and roughness of each film separately, and the effect of irradiation was obvious on the polymer pen, where the presence of black areas was observed on all films.

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تأثير تشعيع كاما على طيف أمتصاص صبغة الفلورسين

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صبغة الفلوريسين ، تشعيع كاما ، استجابة الجرعات، Solvent; Waviness.

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الملخص

في هذه الدراسة تم إذابة صبغة الفلورسين في مذيب داي مثيل فورمايد (DMF) وزنها يعادل 0.0664 و 0.0996 و 0.132 غرام من المادة. باستخدام 5 ملي مول من المذيب ، تم إذابة كل وزن من المادة بشكل منفصل للحصول على التركيز 60 و 80 ملي مول على التوالي. تمت دراسة تأثير كل تركيز وأشعة كاما على الطيف الضوئي لجميع العينات عند درجة حرارة الغرفة. بعد التشعيع وضمن نسبة التركيز المختلفة بجرعة (4.7 كيلوغراي) حيث أظهرت النتائج زيادة الامتصاص مع زيادة التركيز 40 ، 60 ، 80 ملي مول .كذلك وجد أن أطياف الامتصاص تقل عند الطول الموجي 460 و 487 نانومتر مع زيادة الجرعة وطيف امتصاص ثابت بمرور الوقت. لهذا السبب ، تُعتبر هذه التراكيب المتعاقبة مادة فعالة لإجراء قياس جرعات إشعاع كاما في الوقت المناسب درجة الحرارة المحيط.

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