**Production radio-chromic films dosimeter for low and high irradiation dose application**

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Abstract – *The aim of this study is to provide a dosimeter film for industrial and medical applications using different types of dyes with polyvinyl alcohol as support (using a concentration of 10 µm and 30 µm thicknesses of (10, 15, 20 ml), and polyvinyl alcohol (PVA) films were exposure to gamma rays. The films were exposed to different dosage ranges (from 5-60 kGy). Ultraviolet–visible (UV/VIS) spectrophotometer was used to measure the color change of film dosimeter before and after exposure to gamma rays (at 250 to 800nm), Also the film stability was studied at different time periods 1, 7 and 14 days for all films. These films need further studies with different parameters.*

**Keywords:** *dosimetry, radiation detection, dyes, radiation protection*

I. Introduction

Modern radiation therapy techniques attempt to deliver a sufficient and stable dose to malignant tumors while minimizing damage to healthy tissues. As a result, precise dose assessment techniques are required to evaluate the dose distribution of the treatment planning system (TPS) that is created using actual irradiations. Dosimeters that measure the dose in one dimension (1D) include diodes, ionization chambers, thermo-luminescent dosimeters, and MOSFETS. Investigated using polyvinyl butyral (PVB) binder, dosage dosimeters made of film dosimeters with various methyl red MR dye concentrations. Up to 150 KGy of gamma radiation were applied to the dosimeter.1 Films were kept at various humidity levels for three days prior to irradiation in order to study the effect of relative humidity on the dose response of MR-PVA radio chromic dosimeters. Up to 55 KGy, MR-PVA film, a radio-chromic polyvinyl alcohol (PVA) film, was studied. The PVA is an appropriate matrix to use in gamma dose measurements since it is an organic substance that is tissue comparable. When MR-PVA film was subjected to gamma radiation, its hue changed from yellow to colorless.2 By storing the dosimeter films, the impact of humidity during the irradiation was examined for the methyl red-polyvinyl alcohol film dosimeters. The resulting Fricke-Methylthymol blue (Fricke-MTB) dosimeters have a similar diffusion level and less optical scattering as Fricke-OX gels, but they are more sensitive. PRESAGE" and leuco dye gel dosimeters are examples of Fricke-MTB dosimeters that can be photographed with a red **light** source using a Couple-Charged Device (CCD) camera or Optical Coherence Tomography )OCT(3

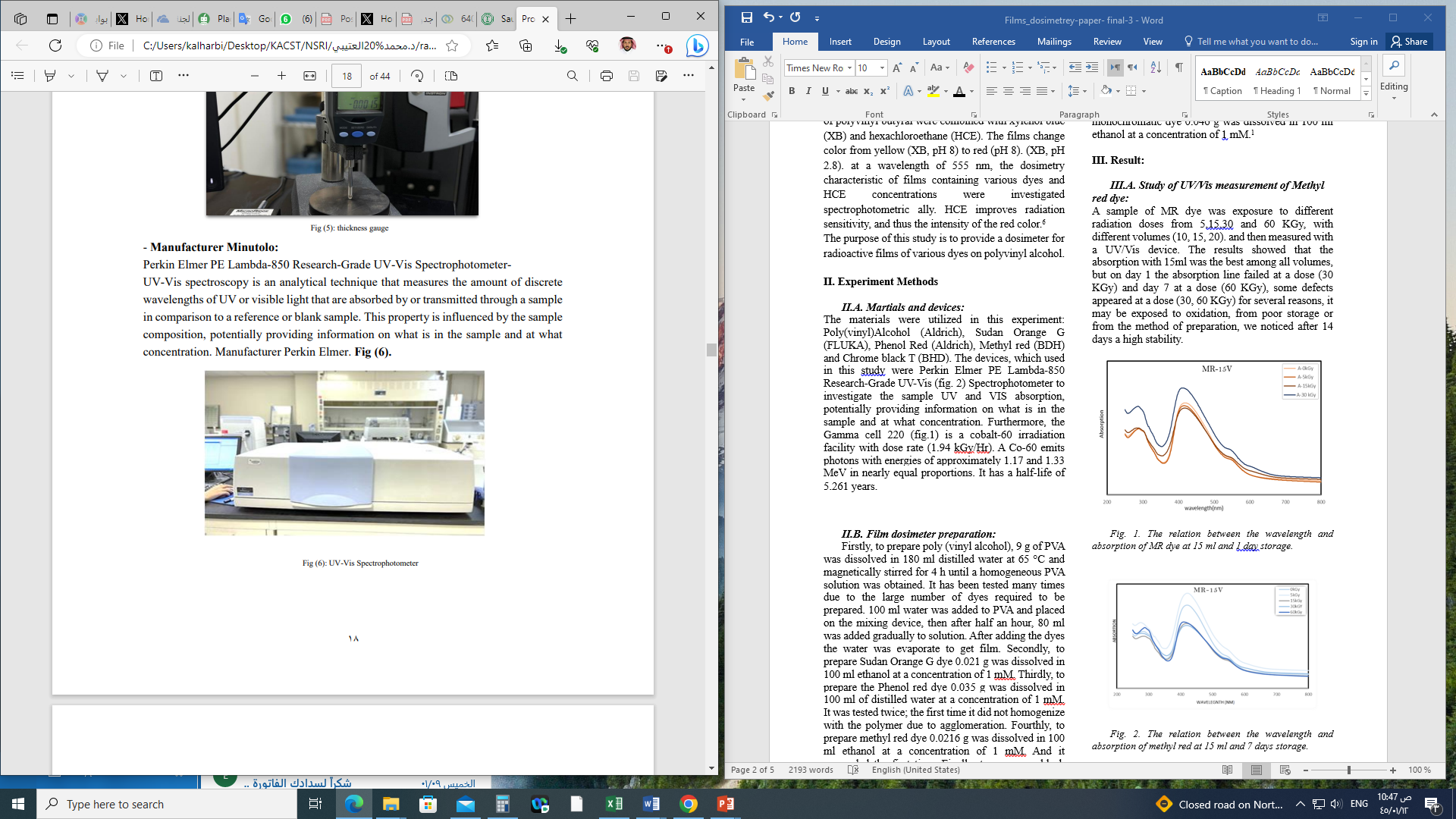
The polymer dyed in the presence of a chlorine-containing chemical, chloral hydrate, was studied using a simple casting procedure of aqueous solutions of polyvinyl alcohol (PVA) containing the dye 2,6 dinitrophenyl (2,6 DNP). The effective dose range is up to 100 Kg.4 when exposed to gamma rays, these films turn white. Dye concentration affects the response of these film dosimeters: added focus. In the presence and absence of some additives, the chemical production of radiation (G-value) is calculated. A new solvent-free film was dosed.5 In different quantities, methyl red (MR) dye was added to poly(chloroprene) (PC). With a maximum wavelength of 55 nm, the films were bright red. At an absorbed radiation dose of up to 30 Kf, the absorption decreased linearly without a noticeable change to the maximum.5 Membranes made of polyvinyl butyral were combined with xylenol blue (XB) and hexachloroethane (HCE). The films change color from yellow (XB, pH 8) to red (pH 8). (XB, pH 2.8). at a wavelength of 555 nm, the dosimetry characteristic of films containing various dyes and HCE concentrations were investigated spectrophotometric ally. HCE improves radiation sensitivity, and thus the intensity of the red color.6

The purpose of this study is to provide a dosimeter for radioactive films of various dyes on polyvinyl alcohol.

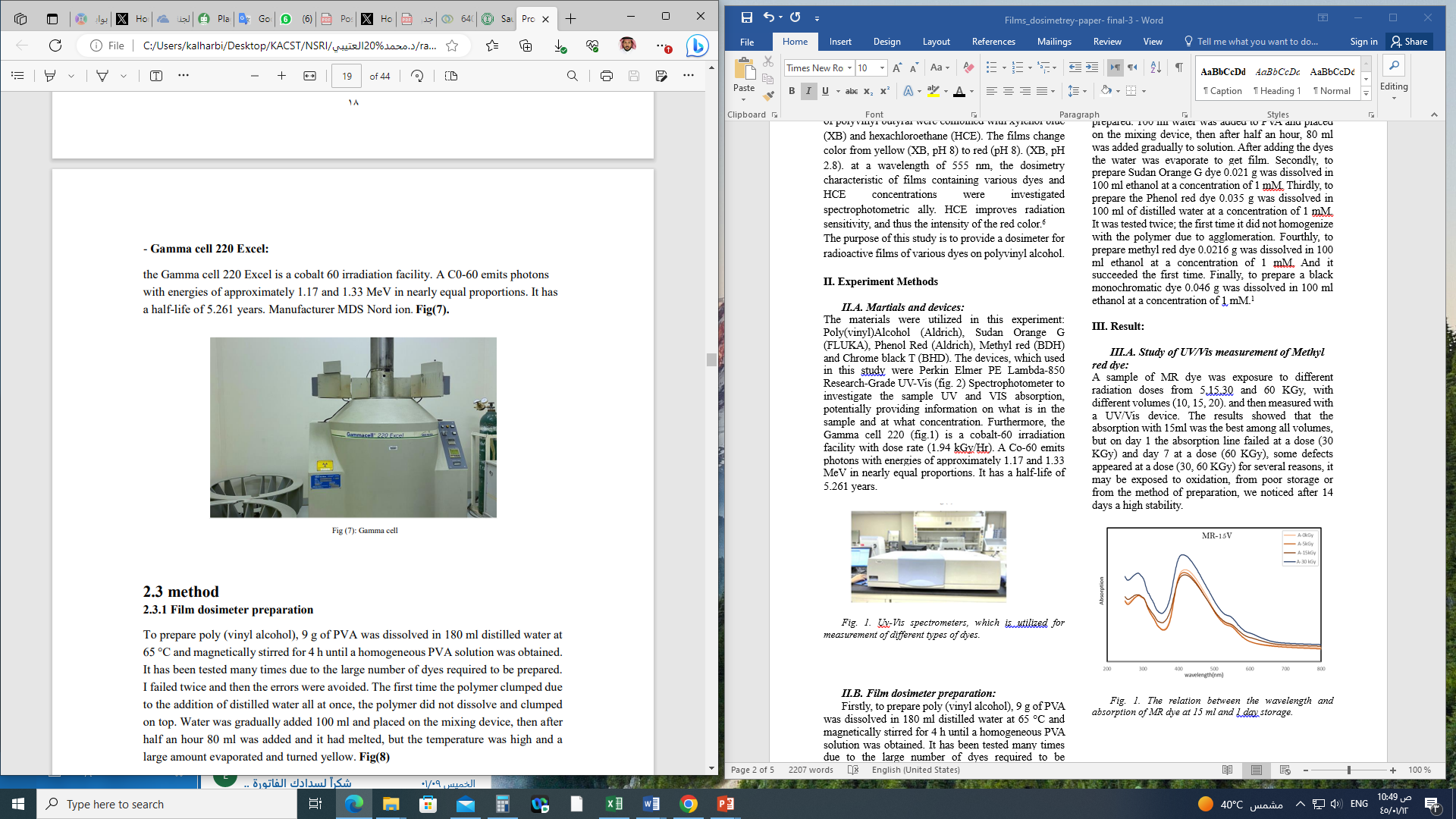
II. Experiment Methods

***II.A. Martials and devices:***

The materials were utilized in this experiment: Poly(vinyl)Alcohol (Aldrich), Sudan Orange G (FLUKA), Phenol Red (Aldrich), Methyl red (BDH) and Chrome black T (BHD). The devices, which used in this study were Perkin Elmer PE Lambda-850 Research-Grade UV-Vis (fig. 2) Spectrophotometer to investigate the sample UV and VIS absorption, potentially providing information on what is in the sample and at what concentration. Furthermore, the Gamma cell 220 (fig.1) is a cobalt-60 irradiation facility with dose rate (1.94 kGy/Hr). Co-60 emits about equal amounts of photons with energy between 1.17 and 1.33 MeV and has a 5.261-year half-life.



*Fig. 1. Uv-Vis spectrometers, which is utilized for measurement of different types of dyes.*



*Fig. 1. Gamma cells was used different radiation does for 5, 15, 30 and 60 KGy in the targeted days.*

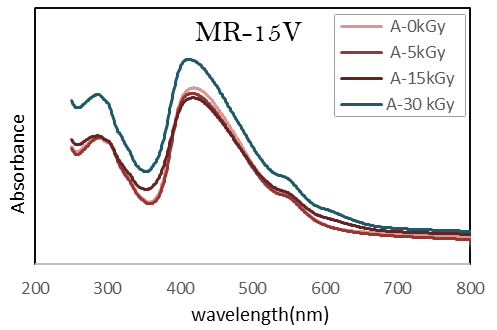
***II.B. Film dosimeter preparation:***

Firstly, to prepare poly (vinyl alcohol), 9 g of PVA was dissolved in 180 ml distilled water at 65 °C and magnetically stirred for 4 h until a homogeneous PVA solution was obtained. It has been tested many times due to the large number of dyes required to be prepared. 100 ml water was added to PVA and placed on the mixing device, then after half an hour, 80 ml was added gradually to solution. After adding the dyes the water was evaporate to get film. Secondly, to prepare Sudan Orange G dye 0.021 g was dissolved in 100 ml ethanol at a concentration of 1 mM. Thirdly, to prepare the Phenol red dye 0.035 g was dissolved in 100 ml of distilled water at a concentration of 1 mM. It was tested twice; the first time it did not homogenize with the polymer due to agglomeration. Fourthly, to prepare methyl red dye 0.0216 g was dissolved in 100 ml ethanol at a concentration of 1 mM. And it succeeded the first time. Finally, to prepare a black monochromatic dye 0.046 g was dissolved in 100 ml ethanol at a concentration of 1 mM.1

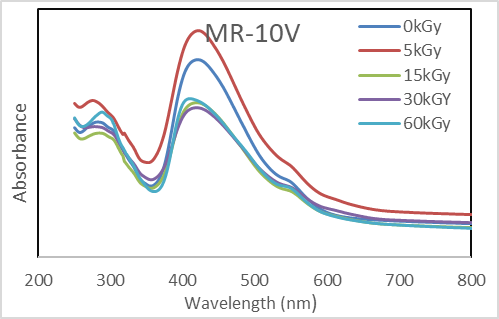
III. Result:

***III.A. Study of UV/Vis measurement of Methyl red dye:***

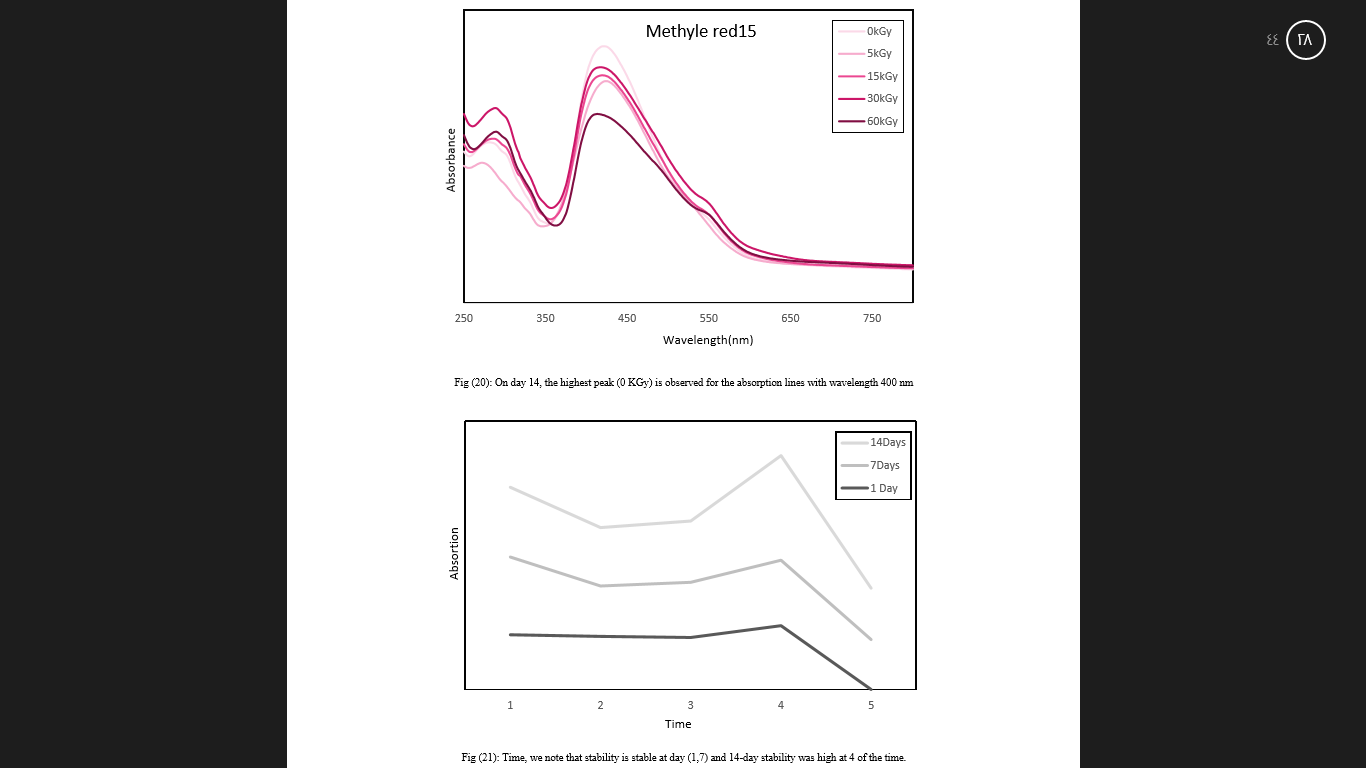
A sample of MR dye was exposure to different radiation doses from 5,15,30 and 60 KGy, with different volumes (10, 15, 20 ml) to made different thickness of each film. and then measured with a UV/Vis device. The results showed that the absorption with 15ml was the best among all volumes, but on day 1 the absorption line failed at a dose (30 KGy) and day 7 at a dose (60 KGy), some defects appeared at a dose (30, 60 KGy) for several reasons, it may be exposed to oxidation, from poor storage or from the method of preparation, we noticed after 14 days a high stability.



*Fig. 1. The relation between the wavelength and absorption of MR dye at 15 ml and 1 day storage.*



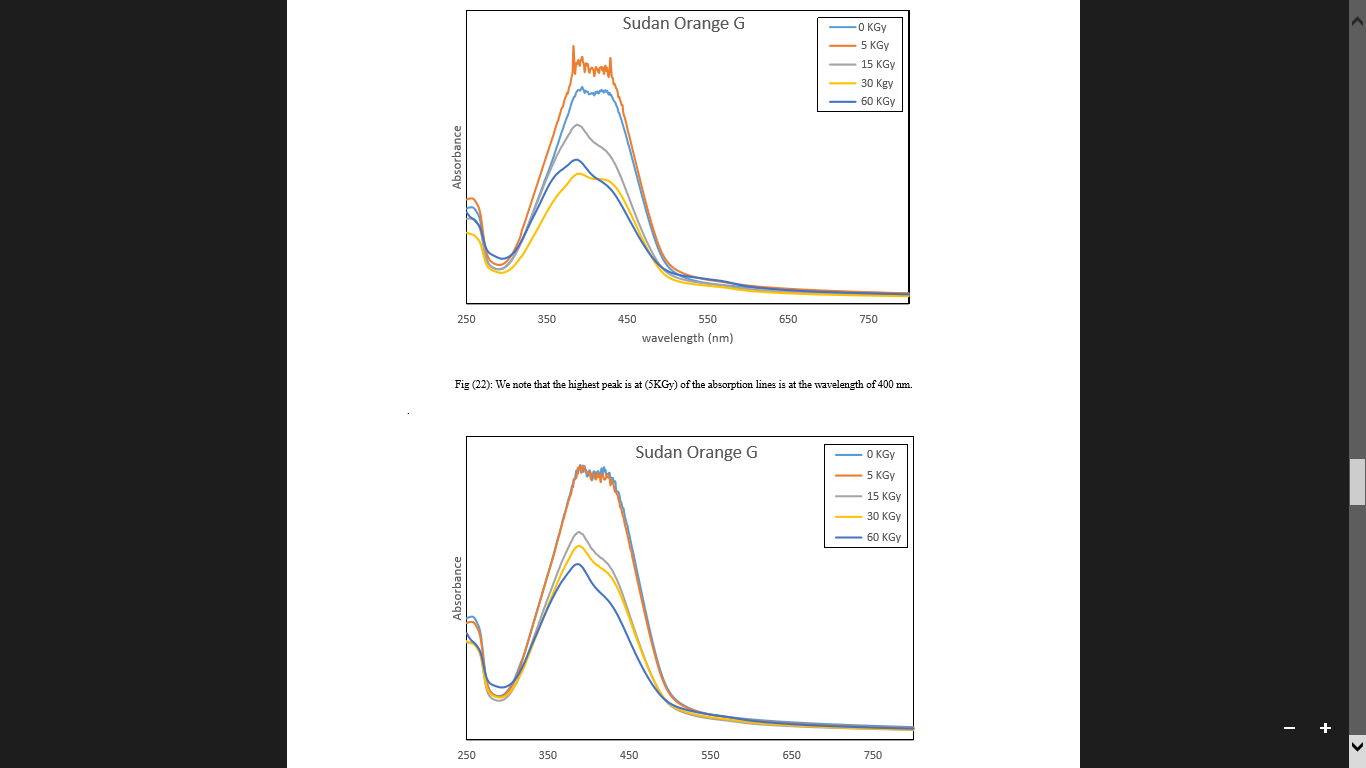
*Fig. 2. The relation between the wavelength and absorption of methyl red at 15 ml and 7 days storage.*



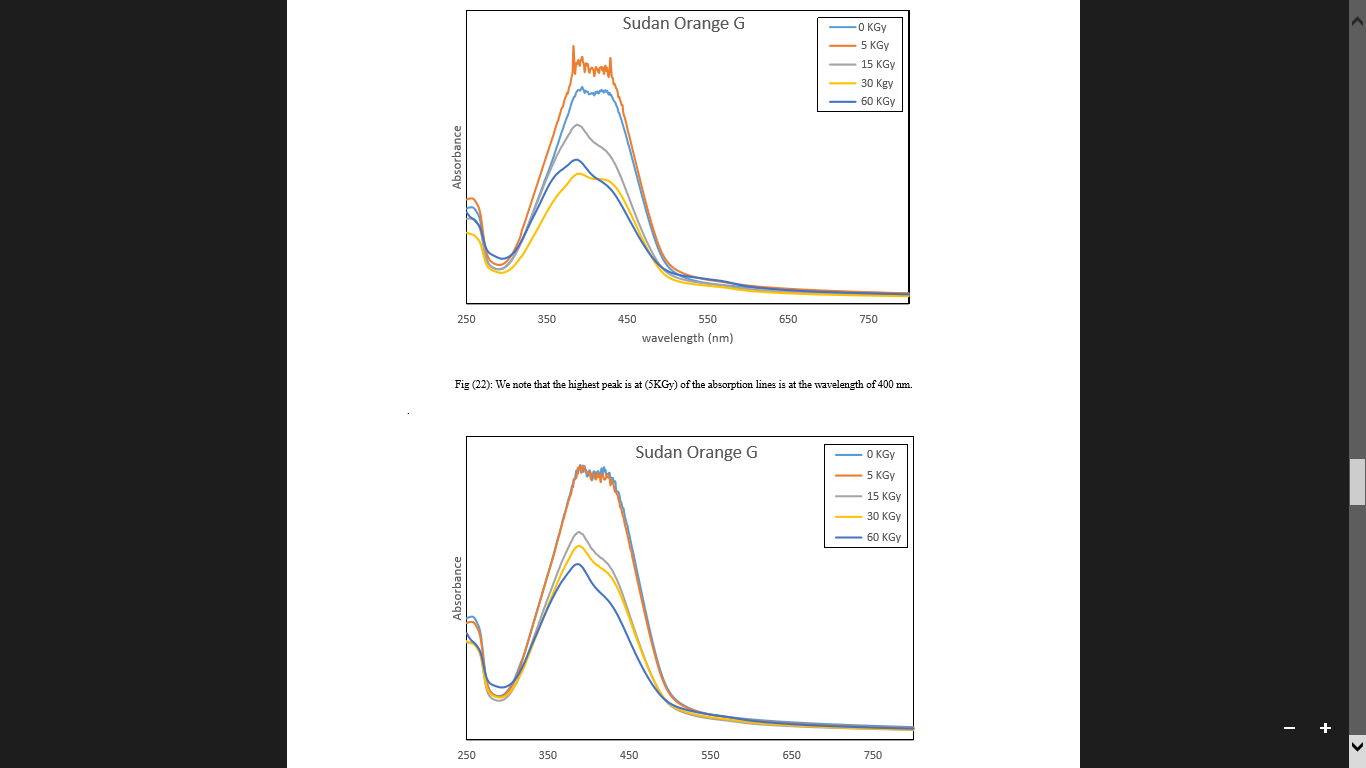
*Fig. 3. The relation between the wavelength and absorption of methyl red at 15 ml and 14 days storage.*

***III.B. Study of UV/Vis measurement of Sudan orange dye:***

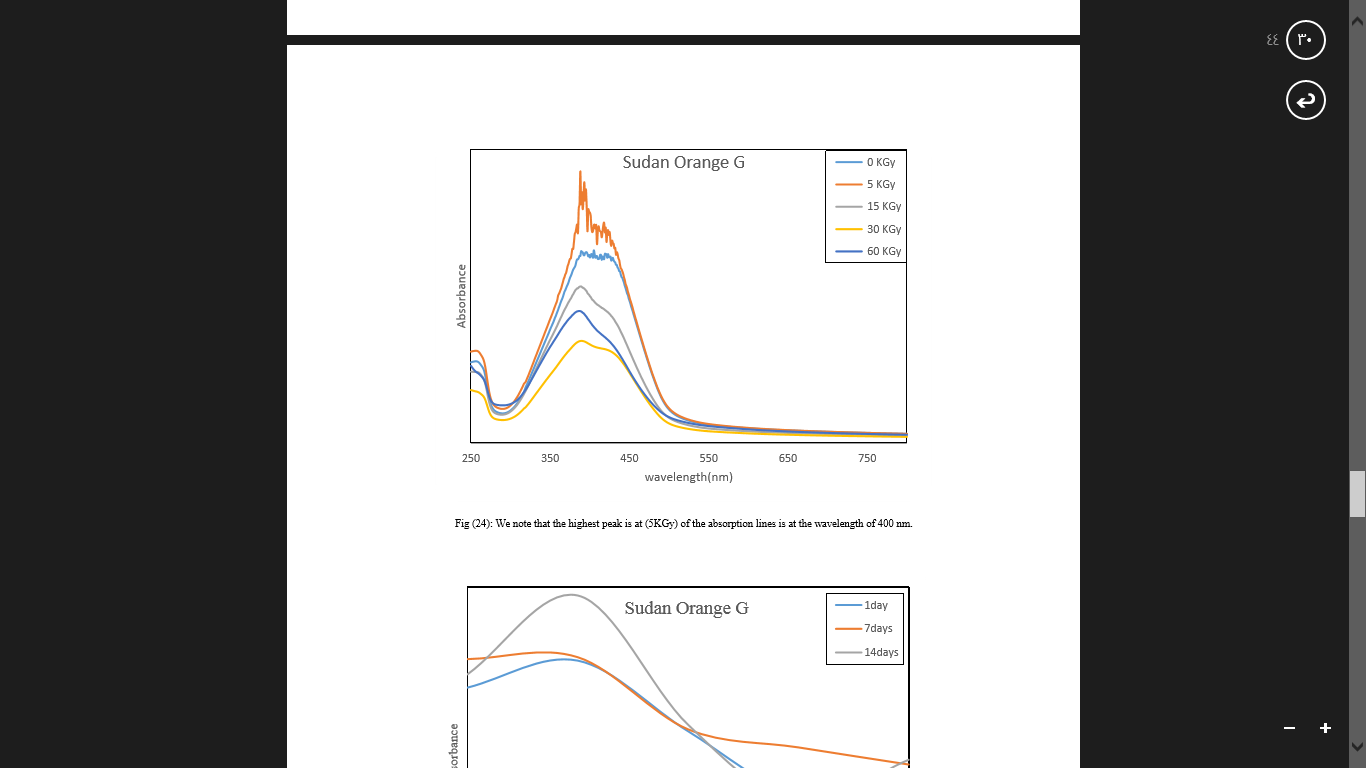
A sample of Sudan orange dye was exposure to different doses range 5,15,30,60 kGy and of different volumes (10, 15, 20 ml), and then the measurement is done with a UV / Vis instrument. The experiment showed that the results of absorption by volume 15 ml at day 1 there were some confusions at the absorption line (5 KGy), and on day 7, 14 exhibited some confusion upon absorption (0 KGy, 5 KGy).



*Fig. 4. The relation between the wavelength and absorption of Sudan orange G at 1 day storage.*



*Fig. 5. The highest peak (0 KGy) is observed on day 7 for the absorption lines with wavelength 400 nm.*



*Fig. 6. The relation between the wavelength and absorption of Sudan orange and 14 days storage.*

***III.C. Study of*** ***UV/Vis measurement of Solo chrome black dye:***

A sample of the black orange dye was exposure to to gamma ray at different doses range 5,15,30,60 kGy at different volumes 10, 15 and 20 ml. and then measured with a UV/Vis spectrometer. It observed that the absorption results by volume 15 were the best, on days 1, 7 and 14 showed high stability.

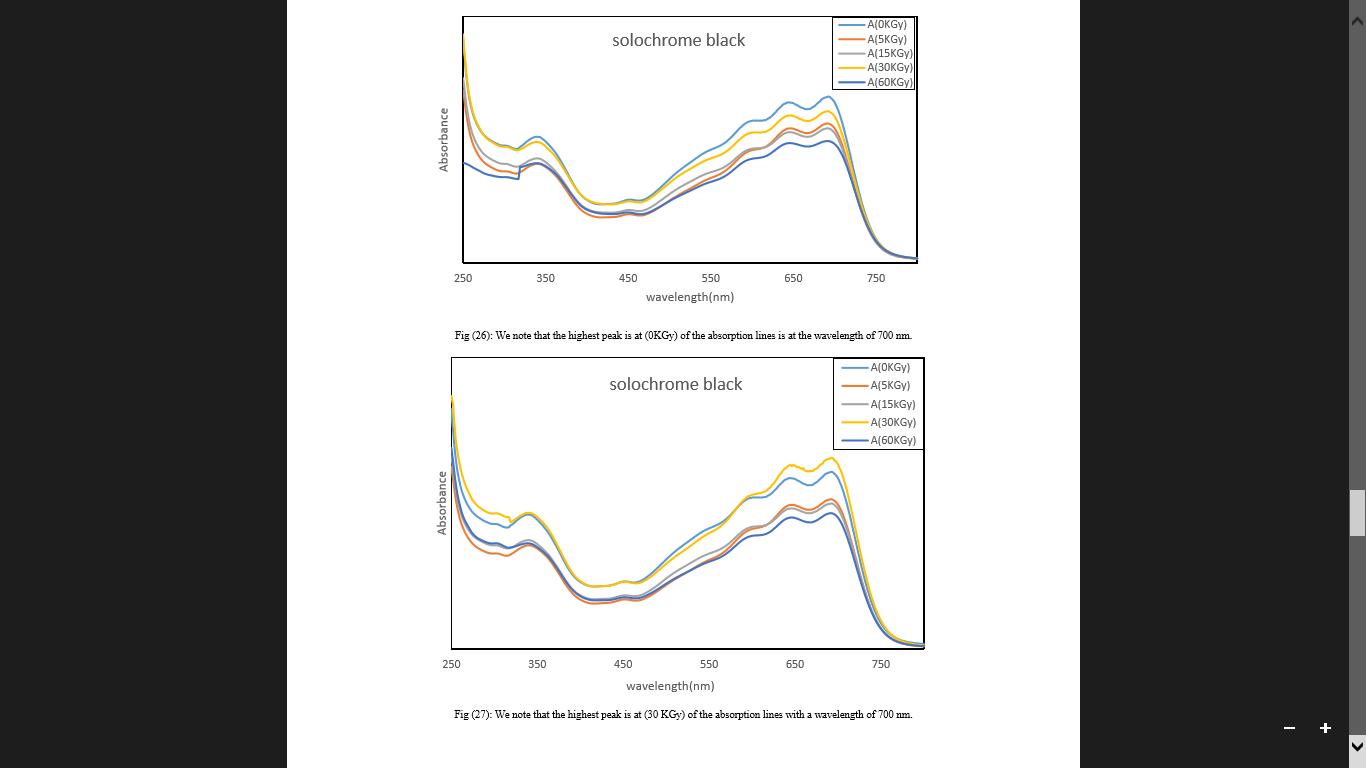


Fig. 7. *The relation between the wavelength and absorption of solochrome black at 1day storage.*

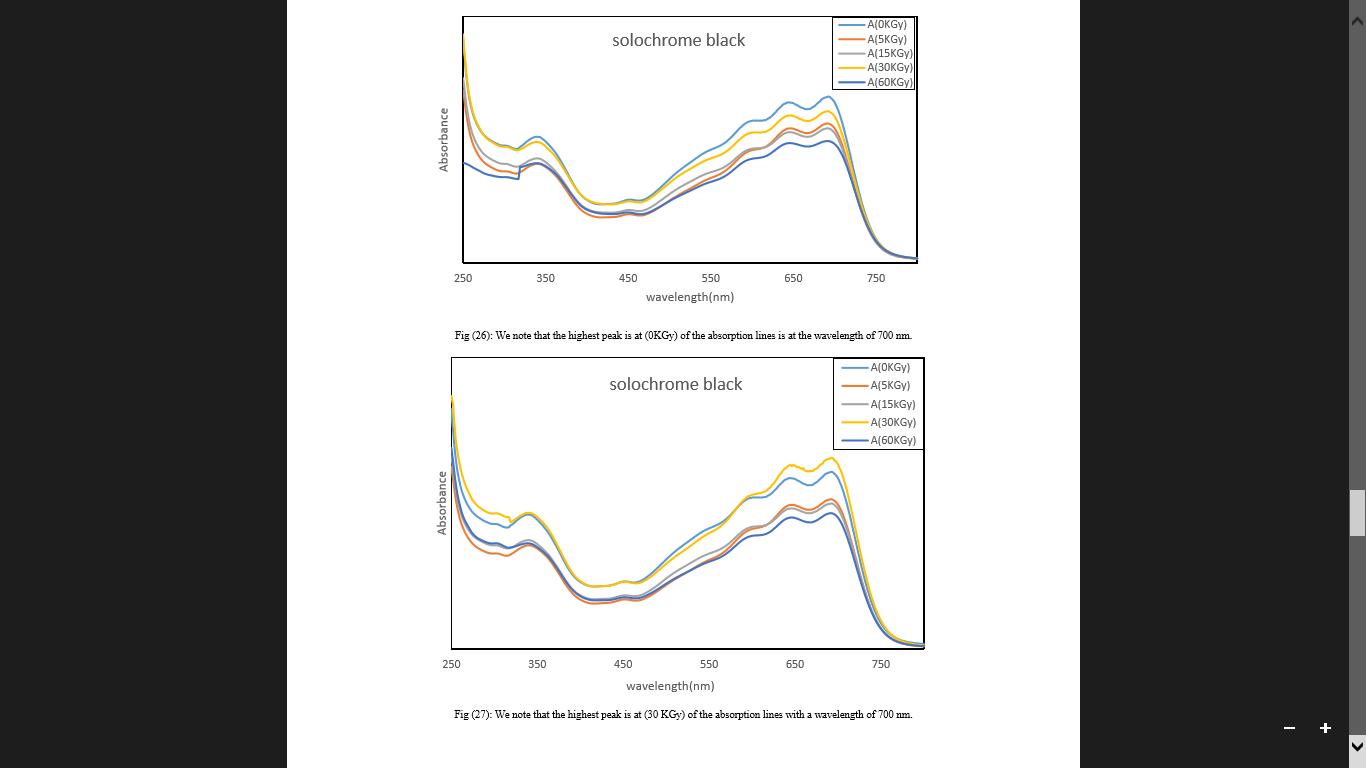
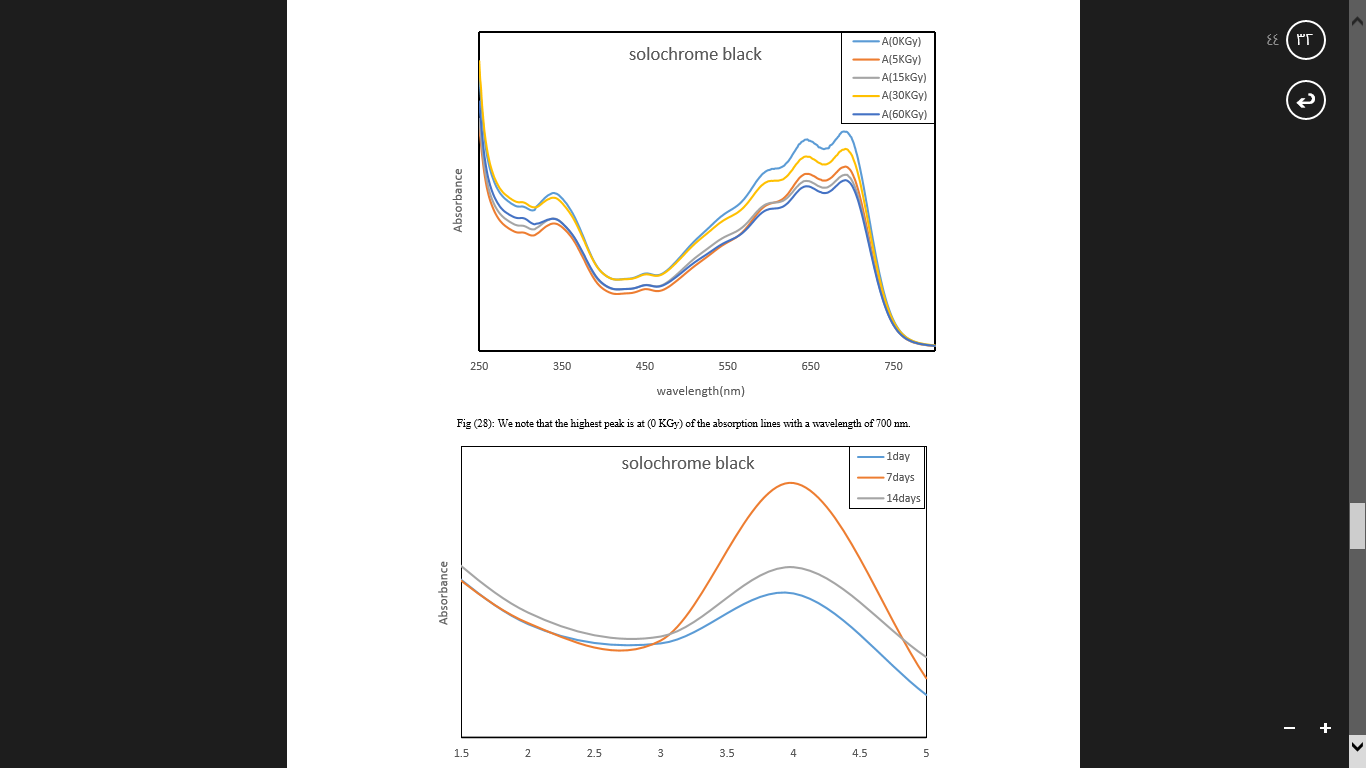


Fig. 8. *The relation between the time and absorption of solochrome black at 7 day storage.*



*Fig. 9. The relation between the wavelength and absorption of solochrom black at 14 days storage.*

***III.D. Study of UV/Vis measurement of Phenolrot dye:***

A sample of the PH dye was taken in doses (5,15,30,60 kg) and in different volumes (10, 15, 20 ml). and then measured with a UV/Vis device. We observed that the absorption results by volume 15 were the best, on days 1, 7 and 14 observing high stability.

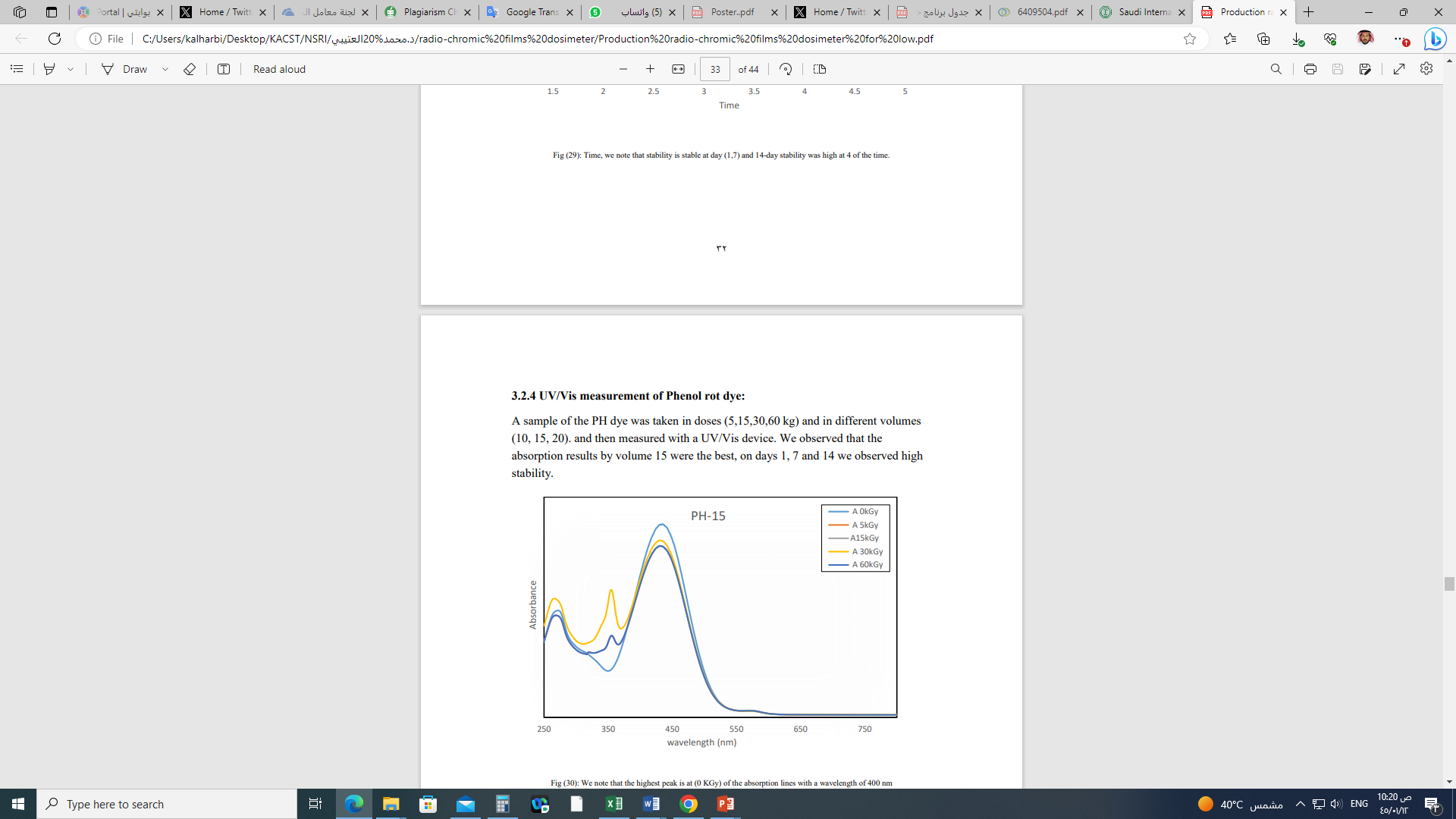


Fig. 10. *The relation between the wavelength and absorption of PH at 15 ml and 1 day storage.*

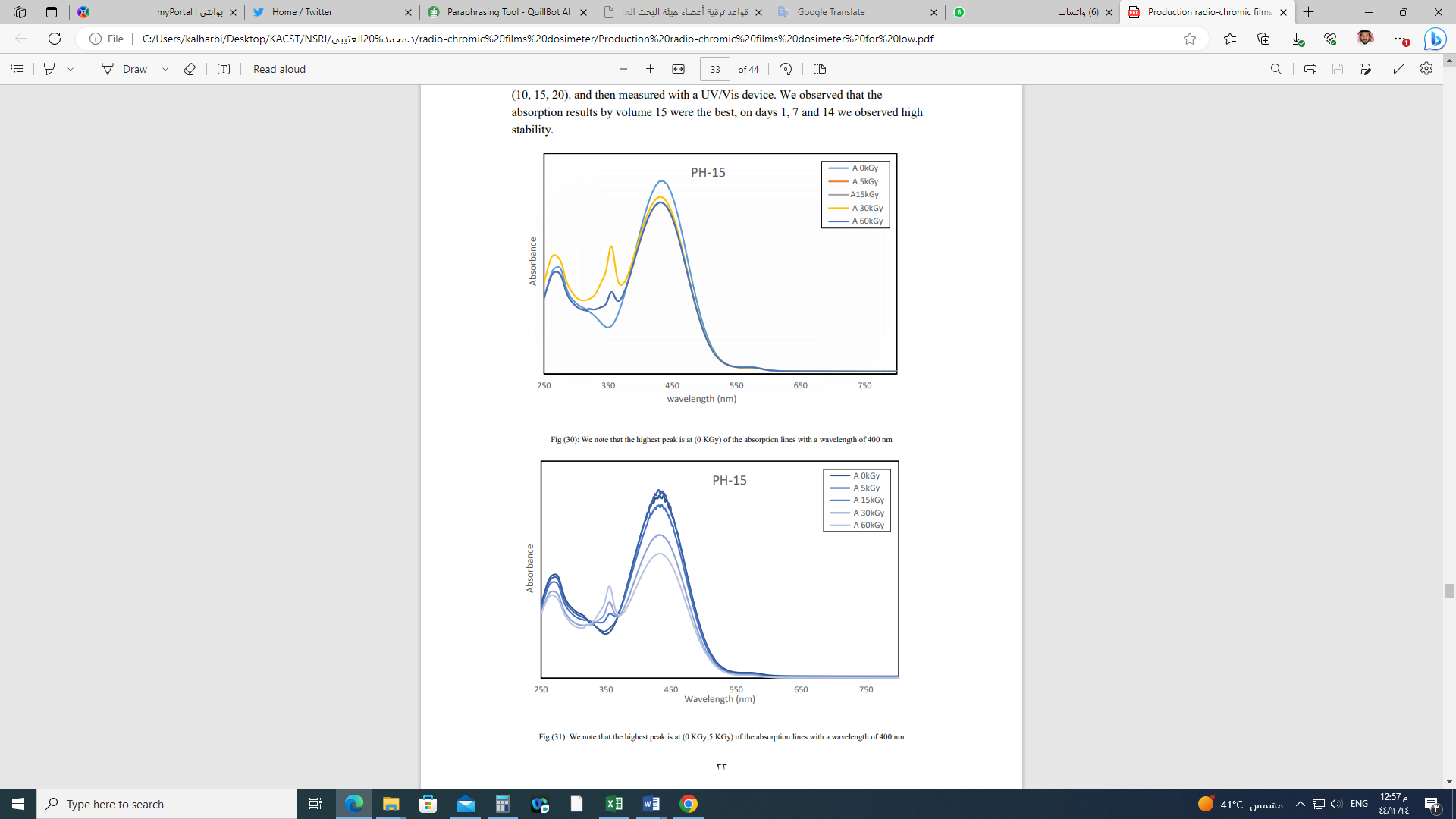


Fig. 11. *The relation between the wavelength and absorption of PH at 15 ml and 7 day storage.*

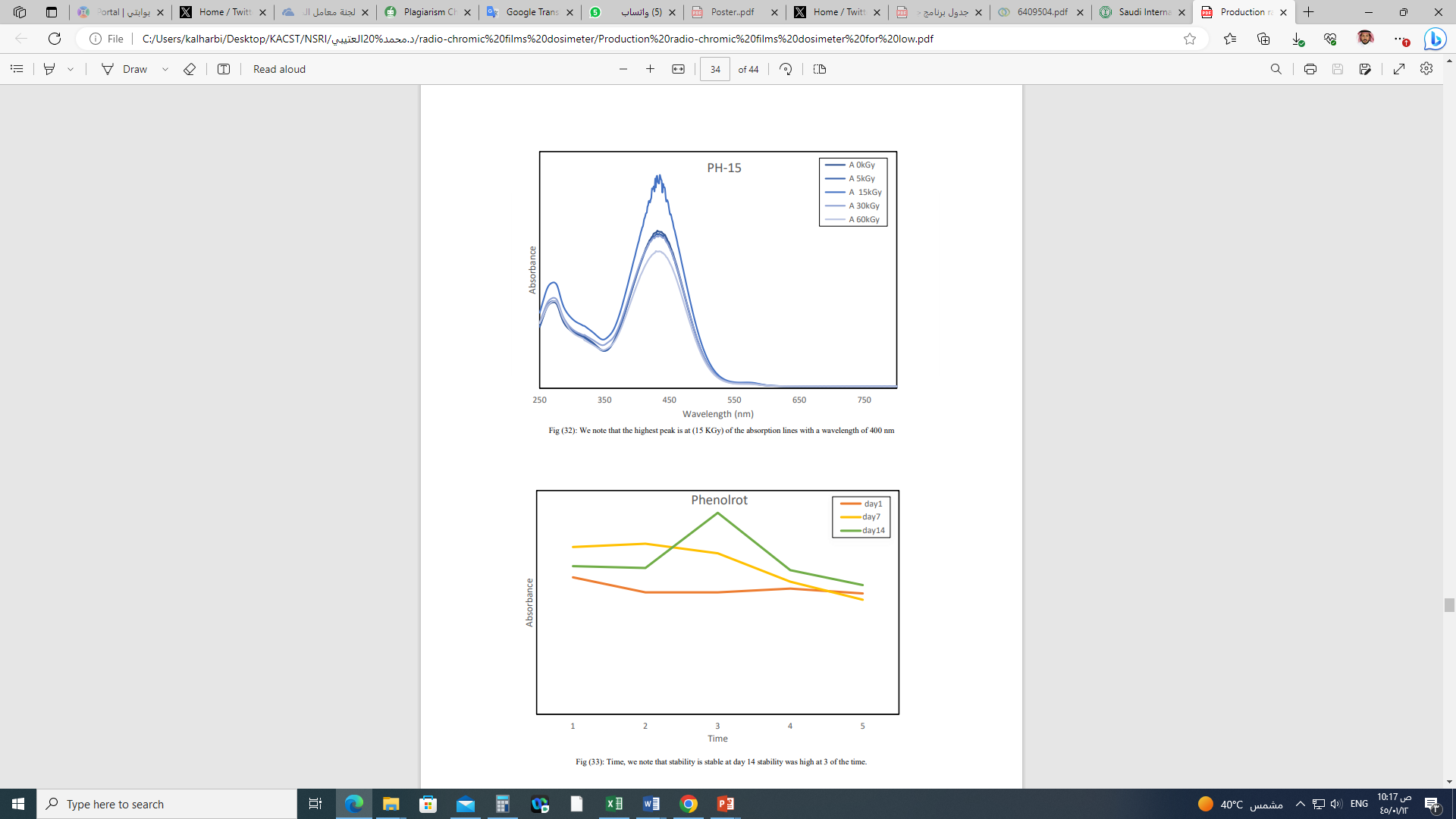


Fig. 12. *The relation between the wavelength and absorption of PH at 15 ml and 14 day storage.*

IV. Discussion:

The color change from black to brown after using 80% of the black dye 11, and it had previously been black. We experimented with a number of dyes, including cocoa, orange, and Ph., but only the cocoa dye was successful. In earlier research, the Ph was also good, and after the funeral, we observed a change in color that ranged from 80 percent to 30 percent. At the dose range of 5–20 kGy with a precision error <0.89%, the solution of methyl red has a good linearity. The methyl red solution indicator is sensitive to the dose of radiation, as evidenced by the color change and the decrease in absorbance value that occurred with increasing radiation dose. The qualitative and quantitative characteristics of the methyl red solution indicator can both be observed. In the qualitative methods, the color change of the indicators was observed, while in the quantitative methods, a UV-Visible Spectrophotometer was used. When stored in dark conditions for up to three weeks before irradiation, the methyl red solution indicator is more stable. After irradiation, it remains stable for up to twelve days., which comparing to our sample MR dye showed that it is the most effective dye that can be used. From previous study, for X-ray irradiation dosimetry applications, a PVA-TCE-CR (Polyvinyl alcohol- Trichlorethylene- Cresol red) polymer film composite has been introduced. Its optical properties were investigated before and after irradiation with X-rays. With increasing the radiation dose, the results showed a physical change. The color of the polymer film changed from purple (pH > 8.8) without radiation (0 kGy) to yellow (almost transparent) (2.8 pH 7.2) at the highest dose (12 kGy), which indicating its effective use as dosimetry.8 Polyvinyl alcohol film dosimeters with various dyes, including Sudan Orange and Roselle (RO). Roselle was extract in cold and hot system (RO-C, RO-H), for dosimeter checking after and before irradiation, with varying thicknesses. They were subjected to gamma rays in the range of 5 to 60 kGy and UV-visible spectrophotometer measurements at wavelengths ranging from 250 to 800 nm for a period of 14 days in order to investigate the film's stability. Irradiation has additional effects, such as raising the melting temperature and increasing oxidation. We utilized the gamma device, which is capable of severing incomplete bonds in various materials. The disease and the dye both gradually alter the color of the dye as the dose varies, with the absorbance value decreasing and the color change becoming less noticeable as the radiation dose and thickness increased.

V. Conclusions:

Different dyes type and concentrations were used to fabricated on PVA film. The dyes used were , methyl red, Sudan orange G, Phenolrot and Solo chrome black at 1 mM concentration were exposure to gamma rays range 5,15,30 and 60 kGy exposed to high and low doses to see the effect of gamma rays and UV rays of the dosimeter before and after exposure to radiation . it was observed that liquid pigments could see the effect of gamma rays in the eye due to the obvious discoloration. A stability study was conducted for all films measured on different times, 1,7,14 days. All showed sensitive to radiation, with the color absorption value decreasing with increasing amount of radiation. The stability of most of all irradiated film at different times was good.

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