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The Feasibility of Reactive Dye in PVA Films as High Dosimeter

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Abstract: The gamma dosimetric response of the Methylene Blue (MB) in Polyvinyl Alcohol (PVA) films was investigated. The spectrophotometric analysis was done to observe the changes in these films at pre and post irradiation. The PVA based films were irradiated using Cs^{137} γ-source within dose range (100-200) kGy. The effect of concentration of dyes, pH of the dyed solutions and thickness of dyed films were employed as the dosimetric parameters in this study. The stability of MB-PVA films before and after irradiation was examined at ambient temperature. MB-PVA films were found to be light sensitive. Owing to simple preparation and absence of any toxic solvents during preparation, PVA based films were found to be docile for large-scale production and application for routine irradiation processes of medical equipments.

Keywords: Thin film, polyvinyl alcohol, methylene blue, γ-radiation.

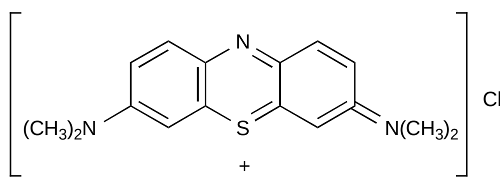
INTRODUCTION

A number of chemical and physical changes are caused in the exposed materials by ionizing radiations [1]. Dosimetry plays an important role in the quality control of radiation processing [2]. The irradiation processing is being used for several purposes, i.e., food irradiation, sterilization of surgical equipment, polymerization and cross-linking of polymers [3]. The diffusivity and surface contamination issues have been actively investigated in the laboratory by different researchers [4, 5]. Therefore, thin film dosimeters are of interest for use in radiation processing because of their convenient characteristics [6]. Polymeric films are lightweight and portable detectors and can be easily put at any location. These films because of their ruggedness, long shelf-life stability, ease of handling and convenient spectrophotometric analysis are usually made available in large reproducible batches [3, 7]. Radiation indicators based on their radiation-induced color change have long been used for identification of irradiated and unirradiated products in radiation sterilization and food irradiation. Due to their sensitivity towards various influencing factors (dose rate, light, humidity, temperature etc.) these are used for quantitative purposes [8].

The current work deals with investigation of film dosimeters made from PVA dyed with methylene blue (MB) to enable their use in processes where high dose of gamma radiations are involved. The films were irradiated with Cs^{137} gamma source. The effects of different parameters i.e., absorbed dose, dye concentration, pH and film thickness on the radiation response of the film dosimeters were discussed.

MATERIALS AND METHODS

Radiochromic dye films were prepared using polyvinyl alcohol powder (PVA) (VWR scientific) containing the Methylene Blue ($C_{16}H_{18}N_3SCl$, MW: 319.9). For simplicity, we will use the notation MB-PVA for the selected dosimetric system. The structure diagram of Methylene Blue is shown in the Figure **1**.



Methylene blue

Figure 1: Molecular structure of Methylene Blue (MB).

Cs^{137}γ-source from Nuclear Institute of Agriculture and Biology (NIAB), Faisalabad, Pakistan having dose rate 660Gy/hr was used for irradiation at room temperature. The samples were irradiated within the dose range 100-200kGy. The UV/VIS spectrophotometer (Perkin Elmer Precisely Lambda 25 UV/VIS) was used to measure the optical absorption spectra of the unirradiated and irradiated films. The film thickness was measured using an electronic digital micrometer with the precision of ±1µm. The pH of the solution was determined by pH meter (3510 pH meter (Jenway).

RESULTS AND DISCUSSION

Absorption Spectra

The optical absorption spectra of unirradiated and irradiated films were measured in the wavelength range

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of 300-800nm using a UV/VIS spectrophotometer. The absorption spectra of MB-PVA films were recorded before and after irradiation to different doses and are shown in Figure **2**.

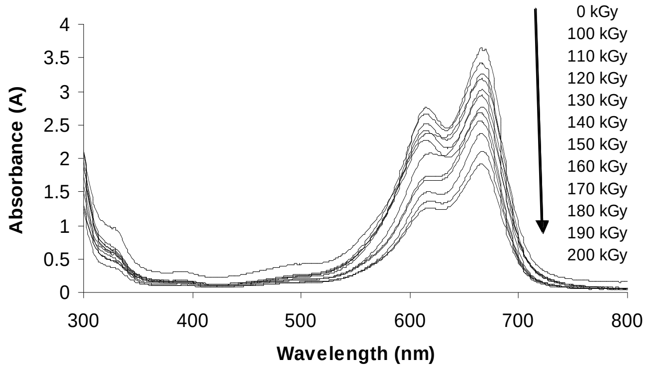

Figure 2: Absorption spectra of unirradiated and irradiated MB-PVA films to different absorbed doses.

The absorption spectrum of these unirradiated films shows a main absorption band in the visible region peaking at 668nm for MB-PVA. The amplitude of these absorption bands decreased gradually with the increasing of dose of γ-rays without changing absorption band maxima.

Absorption spectra of undyed PVA films were shown in Figure **3**. When undyed PVA films were irradiated to dose higher than 150kGy, this produced pale brownish coloration and therefore can be served as a color indicator.

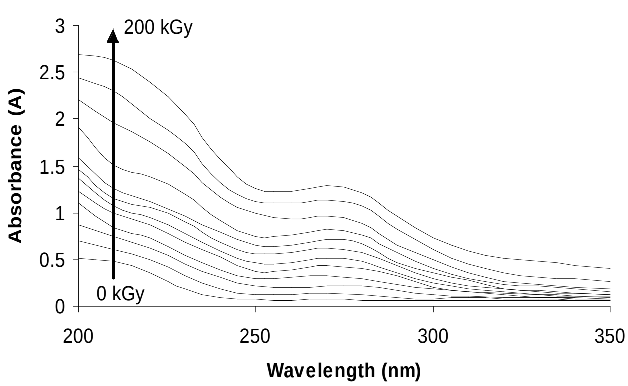

Figure 3: Absorption spectra of undyed PVA films irradiated to different absorbed doses.

Irradiation of Films

It was noticed that the color of films was changed after irradiation with γ-rays. The color of MB-PVA films changed from dark blue to light blue as shown in Figure **4**. This may be due to the difference in the structure of dye. At doses higher than 200kGy, this may be the indicator (colorless).

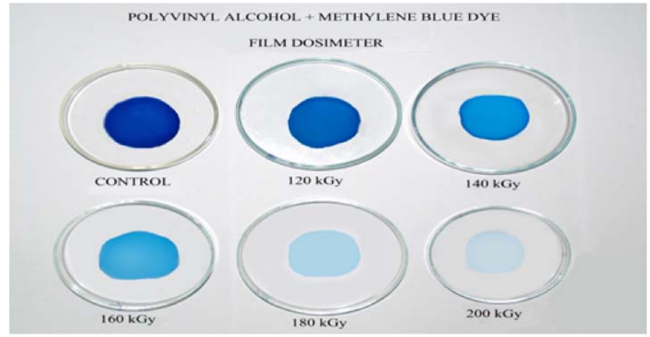

Figure 4: PVA films of methylene blue irradiated to different absorbed doses.

Response Curves

The films were irradiated in the range of 100-200kGy, at room temperature. Figure **5** shows the dose response curves of the films in terms of change in optical density at the λ_{max} per unit thickness, $\Delta A/d$ (mm^{-1}) against absorbed dose; where, d=film thickness and $\Delta A = A_0 - A_i$, giving A_0 and A_i as values of optical absorbance at λ_{max} of unirradiated and irradiated films respectively. Linear relationships were obtained for films of MB-PVA throughout absorbed dose range up to 200kGy.

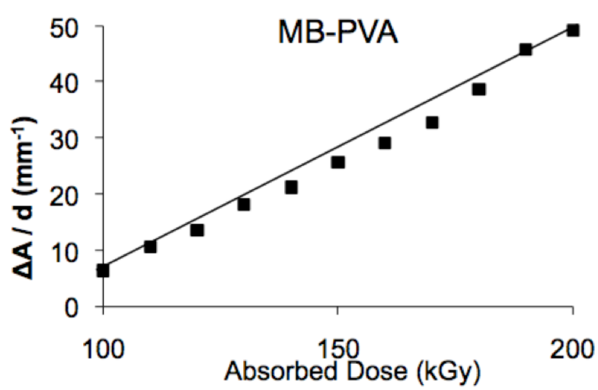

Figure 5: Dose-response curves of MB-PVA at λ_{max} 668nm.

Effect of Concentration

The effect of dye concentration on the response of the dosimeter film, made of PVA solutions containing different concentration of MB such as C_1=0.2gm/L, C_2=0.4gm/L and C_3=0.6gm/L, was investigated. Figure **6** depicts that specific absorbance increases with the increase of dye concentration.

Effect of pH

To study the effect of pH on the response of the dosimeter film acidic (pH2, pH4, pH6) and alkaline (pH8, pH10, pH12) aqueous solutions were prepared to make the dosimeter films. Figure **7** explains that higher sensitivity was observed in the case of the films made from alkaline films. ΔA/d of MB-PVA film was shifted to lower value at pH12.

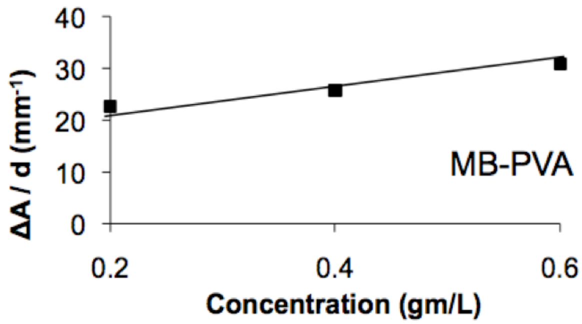

Figure 6: Effect of concentration of dyes on the response (ΔA/d) of dyed PVA films of MB-PVA at λ_{max} 668nm.

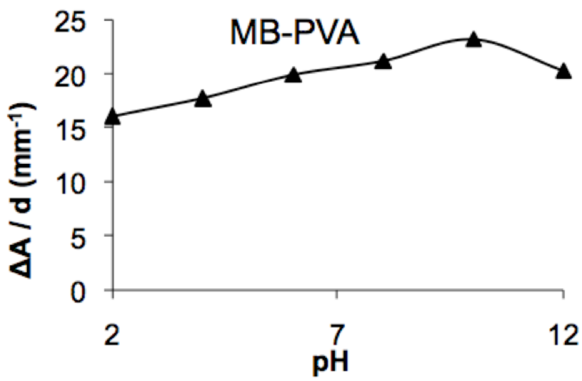

Figure 7: Effect of pH on the response (ΔA/d) of dyed PVA films of MB-PVA at λ_{max} 668nm.

Effect of Thickness

The effect of the film thickness on the response of the dosimeter film was investigated by preparing films of different thickness (0.017, 0.033 and 0.04 mm). It can be seen that with the increase of film thickness, specific absorbance also increases (Figure **8**).

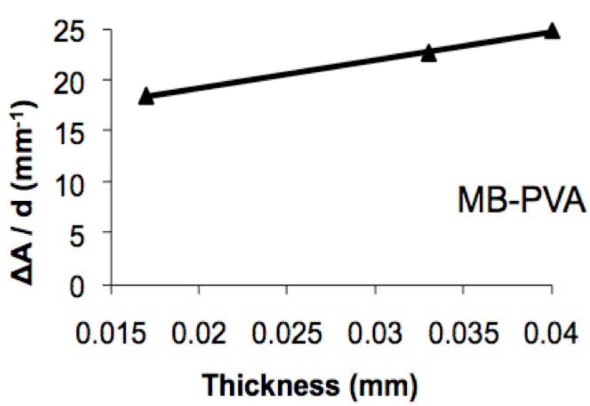

Figure 8: Effect of film thickness on the response (ΔA/d) of dyed PVA films of MB-PVA at λ_{max} 668nm.

Pre-Irradiation Stability (Shelf Life)

Stability measurements before irradiation of the dyed films were made by storing films in darkness and light at ambient temperature. In addition, the films were read spectrophotometrically at different times during the pre-irradiation storage period of 30 days as shown in Figure **9**. It can be seen that the MB-PVA film stored in light showed slightly decrease in absorbance.

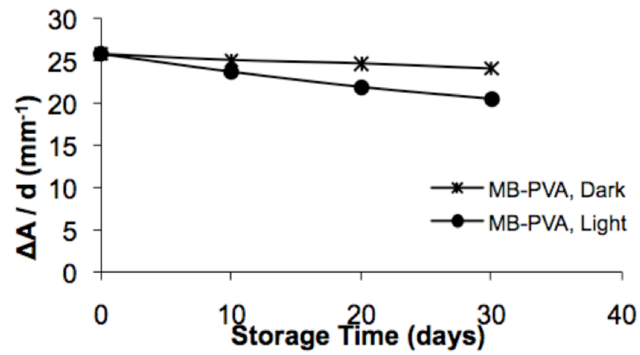

Figure 9: Absorbance values of unirradiated films as a function of time under the storage for 30 days.

Post-Irradiation Stability

The post-irradiation stability is investigated by storing films in the dark and under laboratory fluorescent lights at room temperature (Figure **10**). It was noticed that the irradiated films had a good stability in darkness, But MB-PVA film stored in light showed dramatic decrease in optical absorbance.

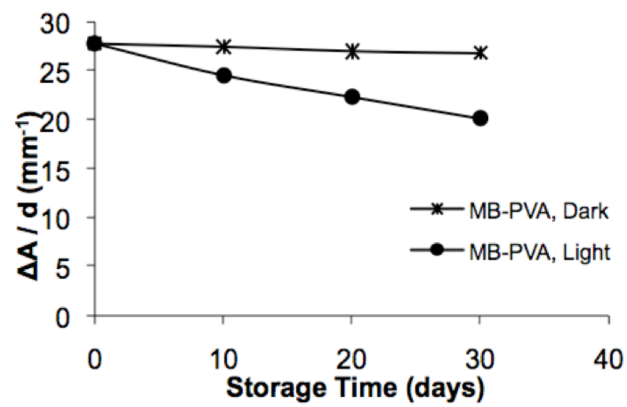

Figure 10: Absorbance values of irradiated films as a function of time under the storage for 30 days.

CONCLUSION

The preliminary study on the PVA based films containing methylene blue dye indicates that radiation induced decoloration of these films can be used for gamma dosimetry. The results indicate that the response of these films depends on the dye concentration, absorbed dose, pH and film thickness. MB-PVA film was found to be light sensitive. PVA based films are easy to make and do not require toxic solvents in their preparation, so therefore, these are docile for large-scale production and application for routine irradiation processes of medical equipment.

REFERENCES

[1] Hussain T, Hussain MY, Shahbaz M, Inam-ul-Haq, Farooq H, Ali S. Radiolysis of commercial dyes in aqueous solutions to produce dosimeters for gamma dosimetry. J Basic App Sci 2012; 8(2): 315-18.

[2] Kattan M, Daher Y, Alkassiri H. A high-dose dosimeter-based polyvinyl chloride dyed with malachite green. Radiat Phys Chem 2007; 76: 1195-99. http://dx.doi.org/10.1016/j.radphyschem.2006.12.004

[3] Bhat NV, Nate MM, Bhat RM, Bhatt BC. Effect of γ-irradiation on polyvinyl alcohol films doped with some dyes and their use in dosimetric studies. Indian J Pure Appl Phys 2007; 45: 545-48.

[4] Shahzad A, He M-G, Kai He. Diffusion motion of two dimensional weakly coupled complex (Dusty) plasmas. Phys Scripta 2013; 87(3): 035501. http://dx.doi.org/10.1088/0031-8949/87/03/035501

[5] Shahzad A, He M-G. Thermodynamics characteristics of dusty plasmas by using molecular dynamics simulations. Plas Sci Technol 2012; 14(9): 771-77. http://dx.doi.org/10.1088/1009-0630/14/9/01

[6] Mai HH, Solomon HM, Taguchi M, Kojima T. Polyvinyl butyral films containing leuco-malachite green as low-dose dosimeters. Radiat Phys Chem 2008; 77: 457-62. http://dx.doi.org/10.1016/j.radphyschem.2007.06.012

[7] Akhavan A, Sohrabpour M, Sharifzadeh M. Preparation of a new chemical radiochromic film dosimeter. Radiat Phys Chem 2002; 63: 773-75. http://dx.doi.org/10.1016/S0969-806X(01)00610-7

[8] Kovacs A, Baranyai M, Wojnarovits L, Slezsa I, Mclaughlin WI, Miller A, Moussa A. Dose determination with nitro blue tetrazolium containing radiochromic dye films by measuring absorbed and reflected light. Radiat Phys Chem 2000; 57: 711-16. http://dx.doi.org/10.1016/S0969-806X(99)00501-0

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