RESPONSE OF SANDAL FIX RED C4BLN DYE SOLUTIONS USING Co^{60} γ-RADIATION SOURCE AT INTERMEDIATE DOSES

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In the present study chemical dosimeters having aqueous solutions of the Sandal Fix Red C4BLN (C.I. Reactive Blue195A) dye were irradiated by Co^{60} γ-radiation source in the range 0-1kGy. Absorbance of exposed samples was studied at λ_{max} of the dye at pre and post irradiation. Radiation interaction with water produced free radicals which consequently increased the acidity of the dye solutions, so the effect of the pH on the response was preferably studied. The proportionality between the absorbance (A) and the concentration (C) of the dye was checked (Validity of Beer's Law). The theoretically proved exponential behavior of the curves between absorbed dose (D) and the absorbance (A) was also taken into account. The exposure of γ-irradiation on the dye solutions showed a linear function with positive slope between the negative logarithm of absorbance (-logA) and the absorbed dose (D). Optimum concentration of the dye was selected from the plotted concentration at which it could be used as the dye dosimeters.

Keywords: Chemical dosimeters, S.F. Red C4BLN, Dye dosimetry, γ-radiation, Optical Density (OD), radiolytic bleaching

INTRODUCTION

Radiation (may be electromagnetic, light photons or ionizing radiations comprised of γ-photons, α or β-particles) is emission and propagation of energy from one point to another from a source to sink. The ionizing radiations can cause biological, chemical as well as physical changes in the exposed matter. So Co^{60} γ-radiation source caused chemical changes in the aqueous solutions of Sandal Fix Red C4BLN (structure given below) in the form of increase in the acidity of the sample solutions (a definite clue of gamma interaction with water). The present study dealt to find a new dye dosimeter of its type. Radiation doses are generally measurable with linear response i.e., the logarithm of the decline in absorbance (-logA) versus the absorbed dose (D), over absorbed dose ranges between 1 and 10^4 Gy, depending on the initial dye concentration, the pH and the presence of additives as alcohols, buffers and inorganic salts (Nasef *et al*., 1995).

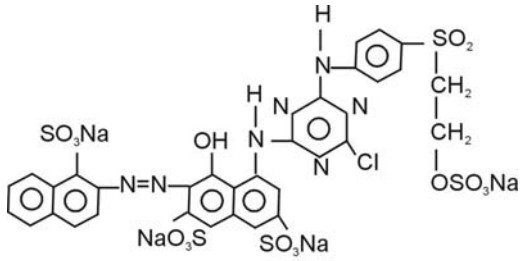

Fig. 1. Structure of Sandal Fix Red C4BLN

This dye is available at Sandal Dyestuff Industries Pvt. Ltd. Faisalabad and relatively a cheap dye i.e., Rs.300/Kg. The aim of this work was to search for the range of irradiation doses at which this dye could be used as dosimeter and to study the response characteristics, the effect of dye concentration on the response, the effect of pH on the aqueous solutions before and after irradiation. The increase in the acidity of the samples due to γ-interaction was also needed to be explored.

SOLUTION PREPEARATIONS

Sandal Fix Red C4BLN ($C_{31}H_{20}N_7O_{16}S_5Na_4Cl$: MW 1033.5) dye was used without further purification. The, 0.0125gms of the dye was weighted by Mettler H35AR (USA) balance and dissolved in one liter demineralized water (collected from Steam Power Station Mananwala, Faisalabad having electrical conductivity less than 1μSiemens/cm). The ready solutions had concentration 12 μmol/L at pH 7.0 measured by Milwaukee SM102 pH-meter. Owing to high solubility of the dye in such polar solvents, it was readily dissolved at room temperature 30 ^{0}C by a glass stirrer. Different concentrations of the dye solutions were prepared such as C_1=12 μmol/L, C_2=6 μmol/L and C_3=3 μmol/L at different pH values such as pH4, pH5, pH6, pOH8, pOH9 and pOH10. 1 Molar solution of sodium hydroxide (NaOH) and hydrochloric acid (HCl) were used to lower and raise the pH values. For irradiation, the dye solutions were held in 5ml glass

ampoules of internal diameter 1.03 cm and thickness 0.18 cm with fit in ground stopper. Co^{60} gamma radiation source (Mark IV Irradiator) from Nuclear Institute of Agriculture and Biology (NIAB) Faisalabad having dose rate 1 Gy/5minutes was used for irradiation. All the samples were irradiated at a fixed position in the gamma flux with the help of a stand. The temperature during irradiation was 25°C. The samples were irradiated for predetermined time according to desired dose. The dye has λ_{max} = 545 nm determined by T80 UV/VIS spectrophotometer.

Beer's Law was verified by plotting the absorbance (A) versus concentration (C) as shown in Figure 2. The absorbance (A) of the samples was measured at the primary absorption peak maxima.

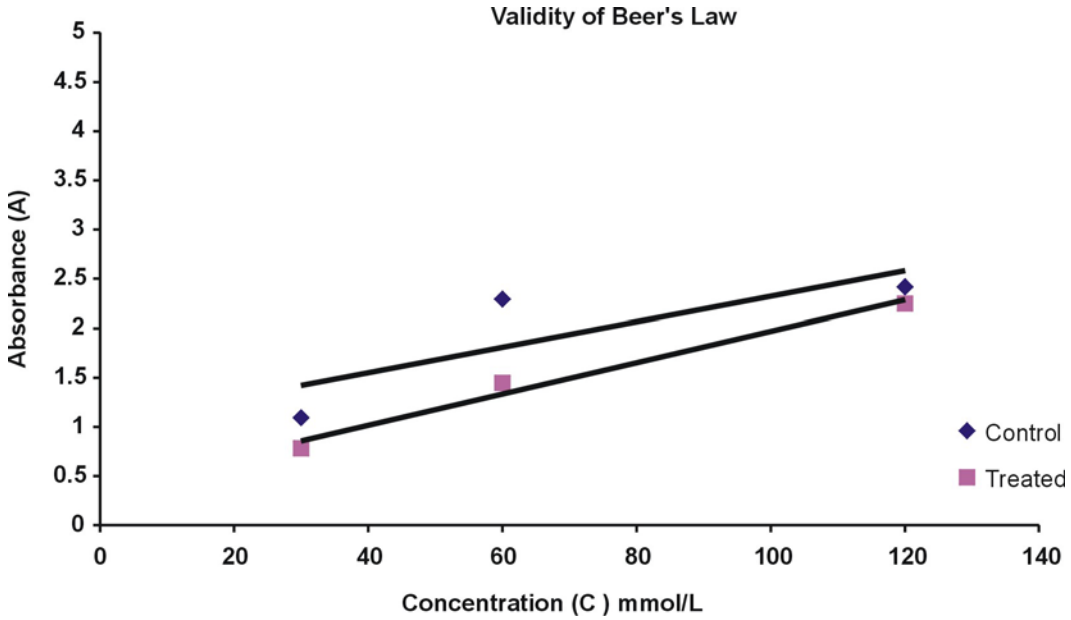

Fig. 2. The linear relationship between absorbance and concentration of the dye solutions

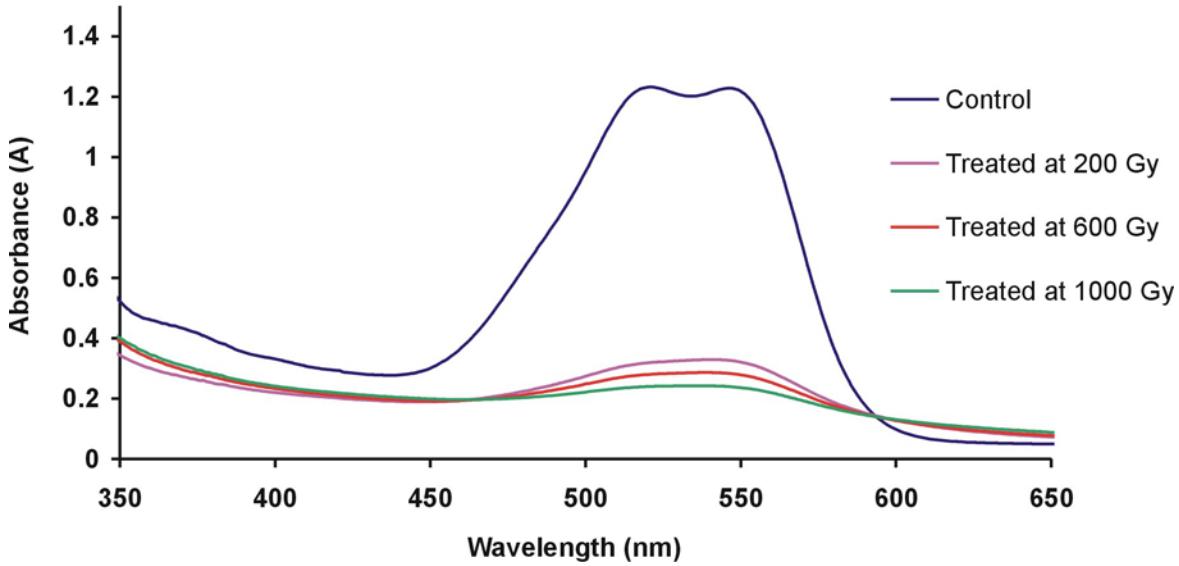

Fig. 3. Absorption spectra of control and treated samples of S.F. Red C4BLN

SOLUTION IRRADIATION AND RESULTS

The optical wavelength (λ_{max}) and the optical density (OD) of the samples were measured with a double beam spectrophotometer using a band pass setting of 1mm. The solutions were held in the object beam in quartz glass, 10mm path lengths cuvette, with the reference beam cuvette containing the demineralized water. Figure 3 shows the absorption spectra of the control and treated aqueous dye solutions.

The decrease in the absorbance (A) as a function of absorbed dose (D) is shown in the Figure 3.

It is obvious from the figure that the radiation induced loss in the dye concentration with dose as a linear fit on a semi-logarithmic plot. Therefore following Beer's Law, it is possible to express the radiation response as follows:

D = -k logA

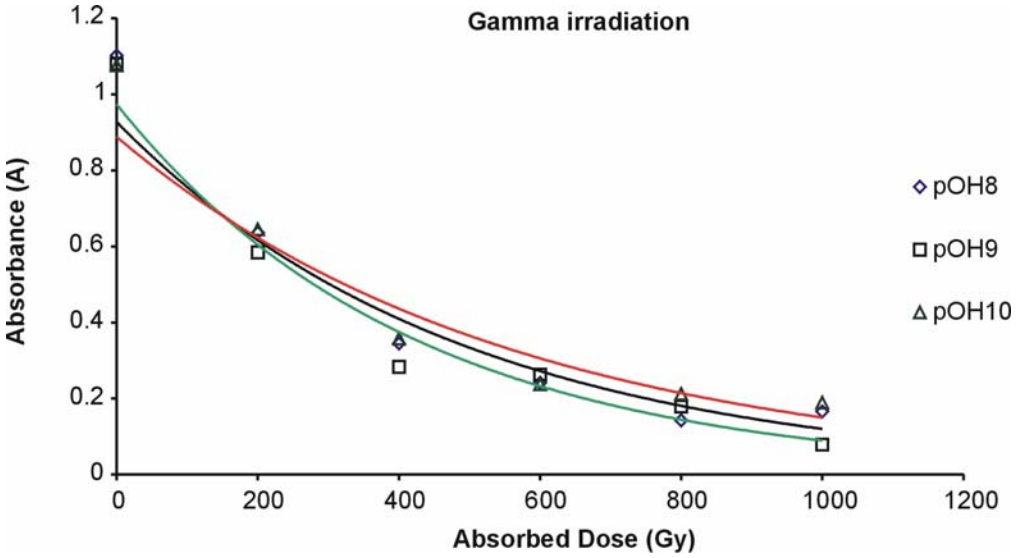

Fig. 4. Decrease in absorbance as a function of absorbed dose

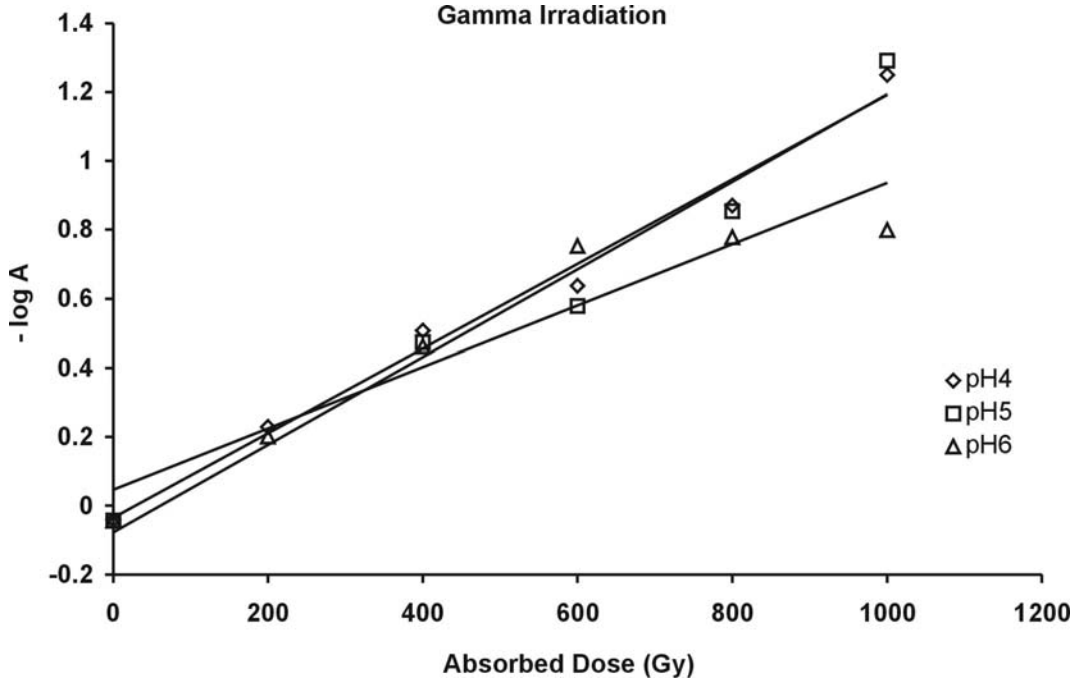

Fig. 5. Gamma radiation response in terms of negative logarithm of absorbance as a function of absorbed dose

The gamma radiation response for the aqueous solutions of the Red in terms of the negative logarithm of absorbance (-logA) as a function of the absorbed dose (D) is shown in Figure 5.

The effect of pH on the response of aqueous solutions of the dye was also studied. The pH of the samples was measured at pre- and post-irradiation. The plot between the absorbance (A) of the samples versus their pH is shown in Figure 6.

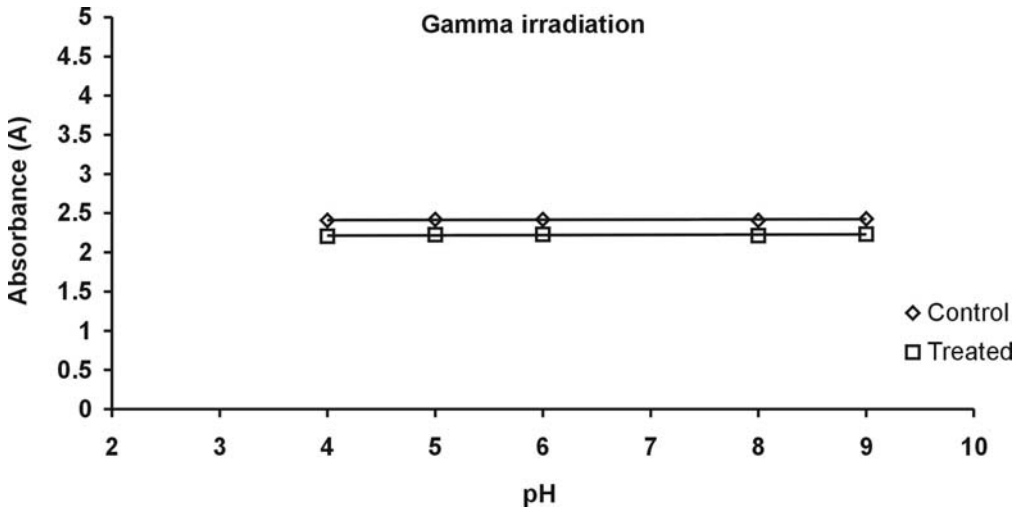

Fig. 6. The effect of pH on the absorbance of the sample solutions

CONCLUSIONS

It was concluded that the aqueous solutions of the Sandal Fix Red C4BLN dye could be used as a dosimeter in the range 400-800 Gy. However, additional studies are still required to increase the working range of the dye, to evaluate the dose rate and energy dependency.

ACKNOWLEDGEMENT

Special thanks to the Director NIAB Faisalabad for providing the irradiation and laboratory facilities. The authors are also thankful to the staff on irradiation facility for cooperation, valuable suggestions and consultancies during the course of this research work, without which this manuscript could have no existence. Moreover, the authors are also thankful to the Chairman and faculty, Department of Chemistry, UAF, for facilitating the accusation of the dye as well as for the scientific and technical help during the course of this research work.

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