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INVESTIGATION OF CYANOSINE B AS GEL DOSIMETER FOR LOW DOSE APPLICATIONS

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ABSTRACT

The Investigation sensitivity of Cyanosine B (CB) – gelatin gel dosimetry system, upon the effect of γ- rays were depicted. Elaboration of (CB) –gelatin gel happens in impartial medium to shape a pink hydrogel, which has a sharp absorbance crest at 549 nm, which is degraded upon increasing absorbed doses. The valuable dose range was 1Gy–300 Gy. All dosimetric studies; dose response, radiation sensitivity, and dependences of the response to environmental factors were investigated.

KEYWORDS: Liquid"Cyanosine B" Dosimeter" **γ** Rays & Low Dose

INTRODUCTION

The irradiated-dose distribution in Fricke-type gel dosimeters has historically been evaluated with resonance imaging (MRI) **Hill et al.,** (2008), with the end goal of 3D radiotherapy dosimetry. Be that as it may, as the subsequent illuminated measurement conveyance diffuses after some time, the assessment system is time-restricted because of the subsequent obscured dosage circulation. Hydrogels can be gotten in different ways. The accompanying techniques are most broadly utilized: synthetic cross-connecting for the most part utilizing glutaraldehyde, as the cross-connecting specialist **Davies, et al.,** (2012); cross-inking by Gamma-irradiation **Martens and Anseth** (2000), by UV radiation **Benamer, et al.,** (2006), also, by utilization of progressive solidness/defrosting cycles **Davies, et al.,** (2012). Gelatin has the upside of dissolving at a lower temperature (around 41˚C) than agarose (around 90˚C), which means less oxygen is lost amid warming that agarose is translucent, while gelatin is explicit, which is essential for optical absorbance estimations **Ajji** (2005). One compound strategy, the gel dosimeter, in which substances conveying dosimetric data are suspended in a gel grid permits dosage appropriations to be measured in three measurements (3D), promising genuine 3D quality affirmation estimations in radiotherapy treatment arranging **Davies** et al., (2012).

This paper aims at the dose response attributes low dose dosimetry system of gel mixture, to search out the foremost appropriate applications.

EXPERIMENTAL WORK

Materials

Four different concentrations of dye (2.4, 4.8, 7.23 and 9.64 μ molL-1) and gelatin concentration is 20 % w/w (that is, the mass of gelatin relative to the mass of the final gel). Gelatin was thawed in distilled water, then the dye Cyanosine B (CB), $C_{20}H_2Br_4Cl_4Na_2O_5$was added from a stock solution. The mixture was continuously afflicted in a water bath. The solution forms a pink color. Since the response rate is reliant on temperature, the water bath was kept up at

70±50C for 4h. This temperature was decided for a quick shading change while keeping the temperature sensibly steady. Tests were pipette into 1 cm thickness glass test tube and quickly set in a cooler at roughly 4 ^{0}C for 4 h.

Apparatus

γ - irradiations were done in a Gamma chamber 4000A ^{60}Co irradiation facility (BARC, India). The absorbed dose rate in the irradiation facility was measured to be 1.37 kGyh^{-1}. Unikan 860 spectrophotometer (KONTRON Co. Ltd., Switzerland) was utilized to quantify the absorption spectra of the unirradiated and irradiated specimens.

RESULTS AND DISCUSSIONS

Absorption Spectra

The absorption spectra of the unirradiated and irradiated depicts absorption band in the visible region peaking at 549 nm (characteristic to a pink color) for dyeing polymer gel (Fig. 1). It is demonstrated that the amplitude of all absorption bands in the visible spectra decreases continuously with increase of the dose of gamma-rays.

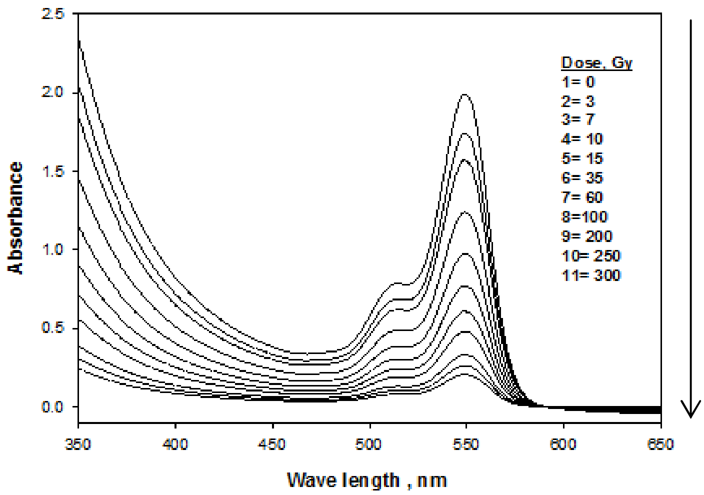

Figure 1: The Absorption Spectra of Unirradiated and Gamma Irradiated (CB – Gelatin) Gel to Different Absorbed Doses

Response Curves

Gel samples were irradiated with dose rate of 1.37kGy/h in the range between 1 and 300 Gy. Moreover, the resulting gel color has an absorbance peak at 549nm this peak degrades upon irradiation as the gel bleaches. Fig. 2demonstrates dose response curves of the gel-dyed samples with different concentrations of CB. Each dose point corresponds to four replicated test tube samples. The dose dependencies are linear up to 10 Gy Fig. 4.44. The linear correlation coefficients were found to be 0.01456, 0.0147, 0.02099and0.0325 for the preparation (dyed-gel) concentrations2. 41, 4.82, 7.23 and 9.64µmolL^{-1}, respectively.

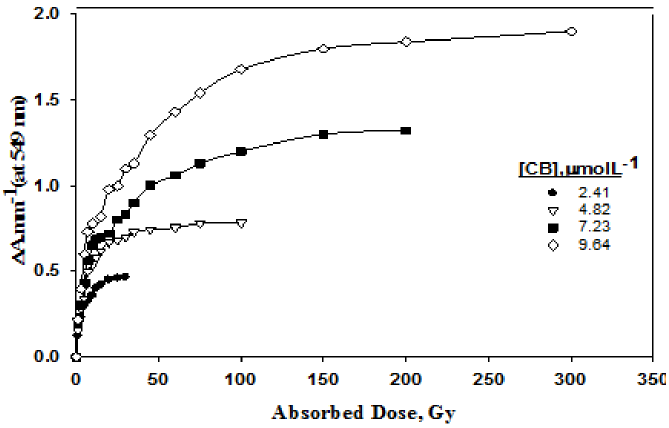

Figure 2: Response Curves of the (CB –Gelatin) Gel at 549 Nm in the Full Dose Range of 1–300 Gy.

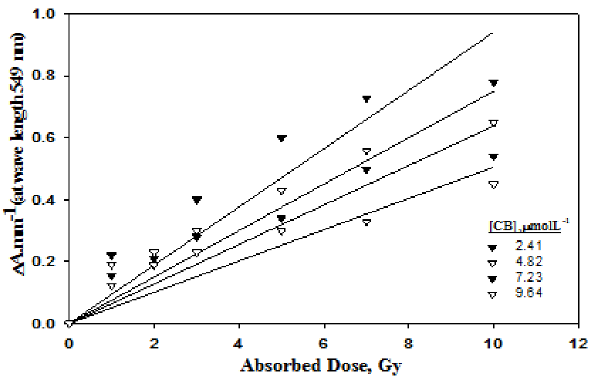

Figure 3: Linear Dose Response of the (CB –Gelatin) Gel at 549 Nm

Radiation, Chemical Yield (G-Value)

By calculating the molar extinction coefficient of (ε), CB had been found to be 20522.1 L. mol^{-1}. cm^{-1}. The radiation, chemical yield (G-Value) was calculated from the linear relation of the response curve (*ΔA* vs. dose). The calculated G-value for these gels and the concentration of the dye inside the solution, were tabulated in table (1). From the table it could be noticed that the G-value increases with the increase in the dye (CB) concentration as shown as in Fig.4.45. This may be due to the number of radiolysis products of polymer (as OH, $H^{\cdot}$, OH^{-}, H^{+},….). This result reflects the important role of the formed free radicals in the bleaching process.

Table 1: The Calculated G-Values for (CB–Gelatin) Gel at Different Dye Concentrations

G-Value ((Cb –Gelatin) Gel), μmol/J	[Cb]. $\mu moll^{-1}$
0.5592	2.4
0.5646	4.82
0.8062	7.23
1.248	9.641

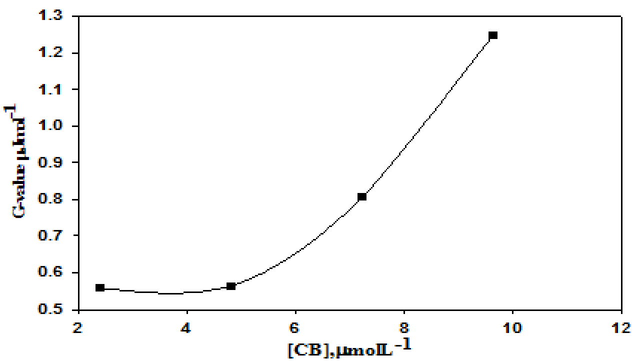

Figure 4: Change of G-Values at 549 Nm as a Function of Concentration of CB Dye

The sensitivity of the gel samples to radiation doses, expressed as the slope of the dose response curve, increases linearly with the dye concentration Fig. 5.

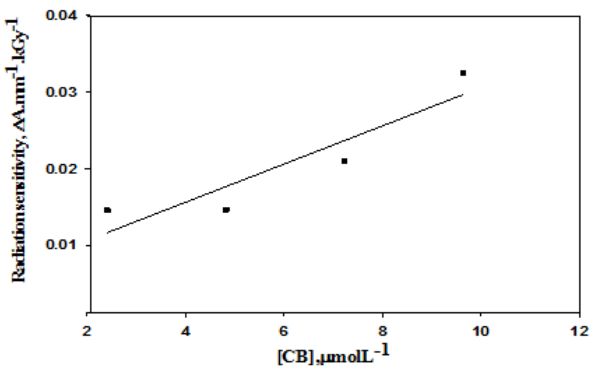

Figure 5: Change of radiation sensitivity at 549 nm of (CB-gelatin) Gel as a function of concentration of CB dye

Optical Energy Gap

Applying (**Urbach; 1953, Mott and Davis; 1979)** the optical energy gap in which the minimum of the conduction band and the maximum of the valance band. The relation between the optical energy gap, absorption coefficient and energy hν of the incident photon.

$$\alpha (h\upsilon) = B (h\upsilon - Eg)^r \quad (1)$$

Where Eg is the optical energy gap; α is the absorption coefficient; B

Is a constant; and r is an index, which can be assumed to have values of 1/2, 3/2, 2, 3, depending on the nature of the electronic transition responsible for the absorption. r = 1/2, for allowing direct transition, r = 3/2 for forbidden direct transition and r = 3 for forbidden indirect transition, and r = 2 refers to indirect allowed transitions. The absorption coefficient for direct transition takes the values from 10^4 to 10^5 cm^{-1}, while the absorption coefficient for indirect transition takes the values from 10 to 10^3 cm^{-1} **(Allan 2012)**. The absorption coefficient α can be calculated according to urbach rule as follows: **(Urbach1953)**

$$\alpha = \frac{1}{L} \ln \frac{Io}{It} \quad (2)$$

Where I_o and I_t are the intensities of the incident and transmitted light respectively, L is the thickness of the sample (cm).

The present results were found to obey equation (1) with r = 2 for all films, which indicate indirect allowed transitions. Values of absorption coefficient were taken between 10 to10^3 cm^{-1}. The $(\alpha h\upsilon)^2$, yielded a linear dependence which describes the allowed indirect transition **(Urbach, 1953; Arshak, A and Zleetini 2002 and Abdel-Fattah et al., 2002)**.

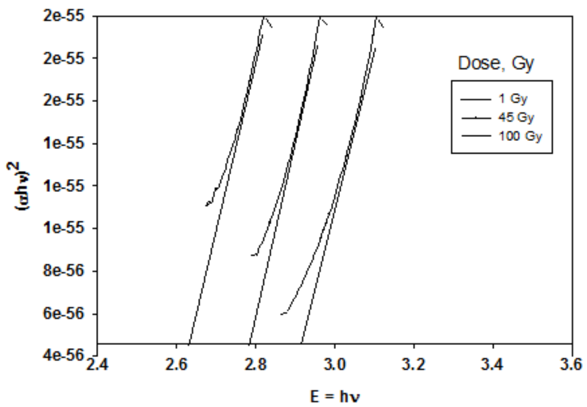

Figure 6: Variation of $(\alpha h\upsilon)^2$ as a Function of HV for CB–Gelatin Gel at Different Doses

Fig. (6) represents $(\alpha h\upsilon)^2$ as a function of the hv for CB – gelatin gel. The gel samples were unirradiated and irradiated to different doses. The optical band gap can be evaluated from the extrapolation of these plots to the point at which they cross the abscissa give the indirect allowed optical band gap. The plots show Eg decreases with increasing absorbed dose.

Fig.(7) represents the value of Eg for indirect transition for CB–gelatin gel. From the figure it can be seen that the Eg decreases with the increase of absorbed dose. The decrease in the band gap energy with increasing dose may be attributed to an increase in structural disorder of the irradiated gel.

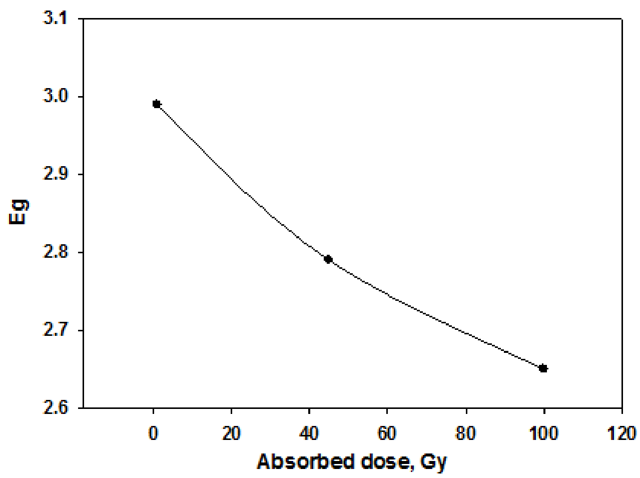

Figure 7: Change in Optical Band Gap as a Function of Absorbed Dose.

Pre-Irradiation Stability

To investigate possible effects of pre-irradiation storage on the prepared gel samples, we monitored absorbance of un-irradiated gel samples stored under different conditions. Two groups of gel samples prepared and their absorbencies at 549 nm were monitored for 36 days. One of the groups was stored at room temperature in the dark and another group was stored at room temperature exposed to laboratory fluorescent light at Fig. 8, the absorbances of the samples stored in the dark at -4 ^{0}C remained essentially unchanged, during the whole period of the observations. The absorbances of the samples stored at room temperature in the dark changed about 1% over the same period of time. However, the absorbances of the gels stored at room temperature under fluorescent light increased approximately 3%, by the end of the observation. So; storage of unirradiated gels in the dark at -4 ^{0}C is recommended.

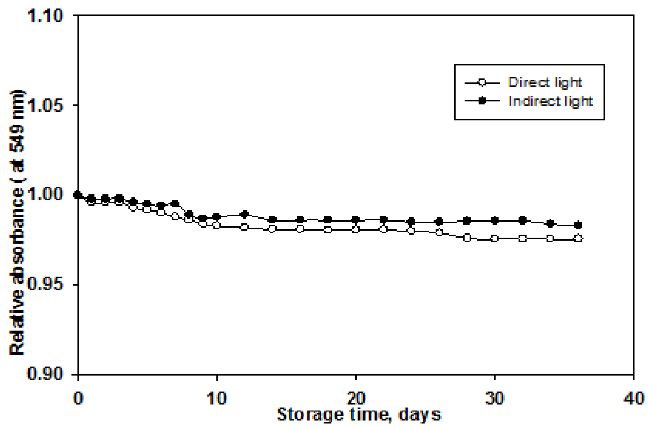

Figure 8: Pre -Irradiation Stability of (CB – Gelatin) Gels Stored Under Different Storage Conditions

Post -Irradiation Stability

CB – gelatin) gels were irradiated with 15 Gy. After the irradiation, they were stored under different conditions. One group was stored at room temperature under laboratory fluorescence light and another group was stored at -4 ^{o}C in the dark. The absorbances of the samples at 549 nm were measured periodically over 36 days of storage Fig. 9. The absorbance of the samples stored at -4 ^{0}C, were very stable over the whole observation period. On the contrary, the responses of the samples stored at room temperature under laboratory fluorescence light, increased rapidly during the first week of storage and then grew more slowly until the end of the observation period.

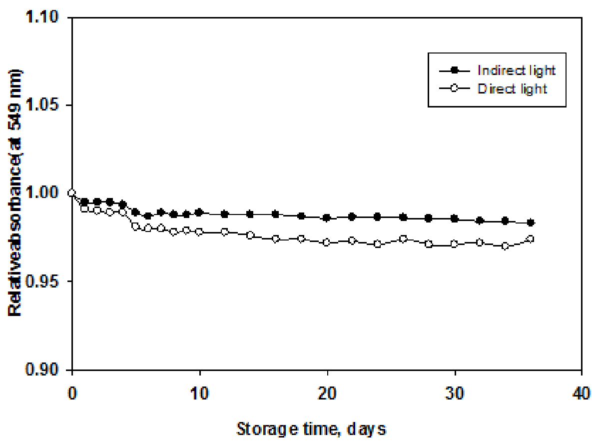

Figure 9: Post -Irradiation Stability of (CB – gelatin) Gels Stored Under Different Storage Conditions (Irradiated at 15 Gy)

CONCLUSIONS

The effect of gamma rays on different concentrations of prepared (CB – gelatin) as gel dosimeter. Upon gamma radiation, the color of the prepared gel (pink color), bleached with the increase of absorbed dose. Moreover, CB gel dosimeter can be applied in the dose range of 2 to 300 Gy that make it apply in seed production, fresh food irradiation, microbial decontamination, radiation treatment of cosmetics, Pathogen elimination of food and spices, and medical sterilization. On the other hand, gel dosimeter has a good stability before and after irradiation during one month only at dark and light. Furthermore, the change in color in gel dosimeters was measured through UV-Vis Spectrophotometer. Finally, many advantages of this dosimeter that is easy-operation, cost-effectiveness, high selectivity and sensitivity, and applicable for many applications as mentioned above

Declaration of Interest

There are no conflicts of interest. We are alone responsible for the content and the writing of the paper.

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