Silver nitrate based gel dosimeter

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Abstract. A new radiochromic gel dosimeter based on silver nitrate and a normoxic gel dosimeter was investigated using UV-Visible spectrophotometry in the clinical dose range. Gamma radiation induced the synthesis of silver nanoparticles in the gel and is confirmed from the UV-Visible spectrum which shows an absorbance peak at around 450 nm. The dose response function of the dosimeter is found to be linear upto12Gy. In addition, the gel samples were found to be stable which were kept under refrigeration.

1. Introduction
In radiation oncology dosimetry is very important [1, 2]. Gel dosimetry is the only three dimensional dosimeter for obtaining the dose distribution [8-10]. With added nanoparticles gel dosimeters have got great scope in radiotherapy as they enhance the dose and have advantages in imaging too. A review on the development of polymer gel has been reported by Baldock *et al* [11]. The different modalities of readout like Magnetic Resonance Imaging (MRI) [12, 13], Optical Computed Tomography (Optical CT) [14], X-ray CT [15, 16], Ultrasound CT (UCT) [17, 18] and vibrational spectroscopy [19, 20] are also discussed. Keeping all this is mind, in this study we have come up with a new dosimeter which works on the effect of radiation on silver nitrate trapped in a normoxic gel. Soliman [21] reported a dosimeter based on gelatin and silver nitrate in which the gelatin acts as the stabilising agent and the proposed gel was studied for its stability post radiation. Silver nanoparticles exhibited dose enhancement effect in MAGIC gel dosimeter [22]. It has got anticancer properties [23] and is less expensive compared to the high atomic number nanoparticles (Gold, Platinum, Bismuth, etc.) which are commonly used for dose enhancement [24]. Hence, the present study is based on radiation sensitive silver nitrate and PAGAT gel dosimetry irradiated with Cobalt-60 source in the clinical range. In this study we chose a normoxic PAGAT gel [25-27], as it is easy to prepare and is tissue equivalent and stable. PAGAT gel along with the silver nitrate samples were irradiated with different doses. The aim of the study was to evaluate the silver nitrate doped PAGAT gel using UV-visible spectrophotometer.

2. Materials and Method

2.1. Gel Preparation
PAGAT gel chosen for our study was prepared at normal atmospheric conditions as reported by [28]. The ingredients consisted of 89 % of distilled water, 3.5% (w/w) N'N- methylene bisacrylamide, 3.5% (w/w) acrylamide, 5% (w/w) of gelatin and 10mM of Tetrakis (hydroxymethyl) phospohonium chloride.

Silver nitrate was added at the end of PAGAT preparation at a concentration of 250 mM [21]. After preparation, the gels were filled in plastic cuvettes of 4.5 ml volume and the cuvette openings were sealed with transparent adhesive tapes to prevent oxygen entry. The samples were covered with silver foil to avoid auto reduction by light. Plain PAGAT and PAGAT with silver nitrate were prepared. The samples of gelatin and silver nitrate were also made as reported [21]. All the samples were kept in refrigerator overnight for proper gelation.

2.2. Gel Irradiation

Gel samples were irradiated with Cobalt-60 (Theratron 780c). Source to surface distance (SSD) was maintained at 80 cm with the field size of 10 x 10 cm^2. Samples were irradiated from 3 Gy to 12 Gy in the range of 3 Gy intervals. Before and after irradiation, the samples were maintained at 4 degree Celsius for 24 hours to attain complete reduction.

2.3. UV Spectrophotometry for PAGAT

U2800-Hitachi was used for UV Spectrophotometry of the gel samples. The samples were read after 24 hours prior to radiation. The 0 Gy sample, which is the unirradiated gel, was taken as the control for the irradiated gel and the same was used for the baseline correction for UV-visible spectrophotometric analysis. 350-800 nm was selected as the range of absorption wavelength with 1nm interval.

2.4. Linearity and Stability

The dose response function of the prepared gel dosimeter was plotted against the different dose levels. And UV- Visible spectrum was taken for the gel samples every alternate day for two weeks

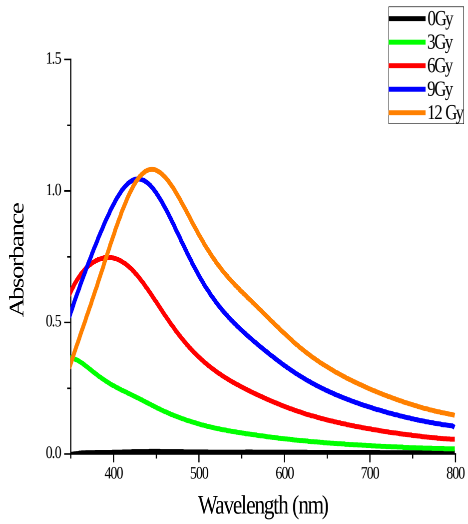

Figure 1. UV- vis spectrum of PAGAT gel.

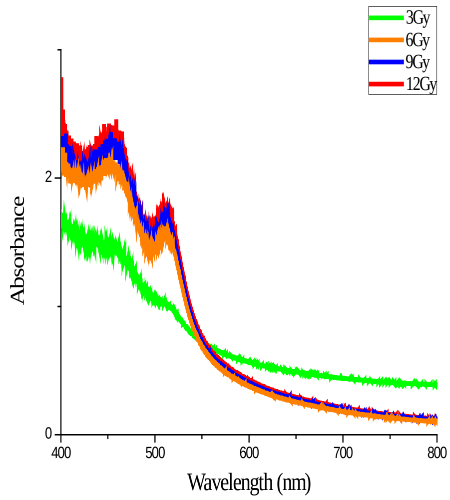

Figure 2. UV-visible spectrum of Gelatin+ $AgNO_3$.

3. Result and Discussion

3.1. UV-visible Spectrophotometry Analysis

The absorption spectrum of PAGAT gel for different dose range can be clearly seen in figure 1. No other peaks were seen for doses up to 12 Gy. Figure 2 illustrates a spectrum similar to as reported [21]. It gives the spectrum for gel samples made with gelatin and $AgNO_3$ with a concentration of 250mM which is considered as the optimum concentration. The irradiated PAGAT and PAGAT+ $AgNO_3$ can be seen in figure 3a and 3b a spectrum analogous to figure 2 is seen in figure 5 which depicts PAGAT + $AgNO_3$ gel. A peak at around 450 nm indicates silver nanoparticle presence, the surface plasmon resonance peak of silver. A second peak at around 510 nm can also be seen which may account for the increase in size of the nanoparticle which is due to agglomeration [21]. The absorption intensity increases with the radiation dose without much shift in the position of the peak

Visually, there has been a color change from light yellow to dark brown as the dose increases as seen in Figure 3a and 3b. Soon after the preparation the gel sample turned light yellowish indicating the formation of silver nanoparticles because of the heat during the gel preparation.

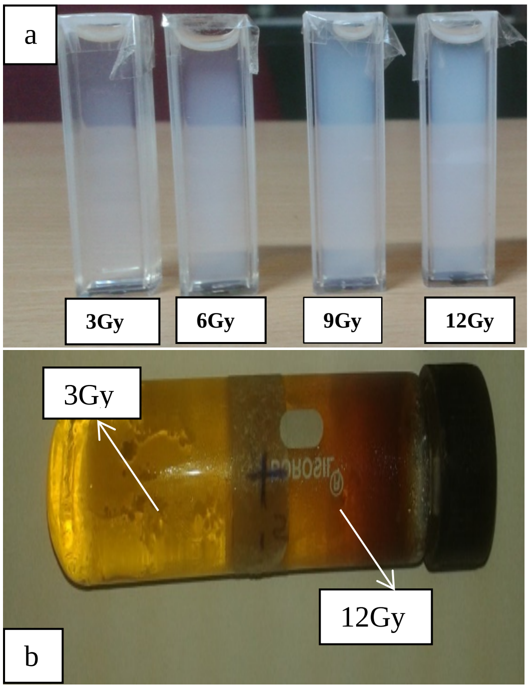

Figure 3. (a) Irradiated PAGAT gel.
(b) Irradiated PAGAT+$AgNO_3$ gel.

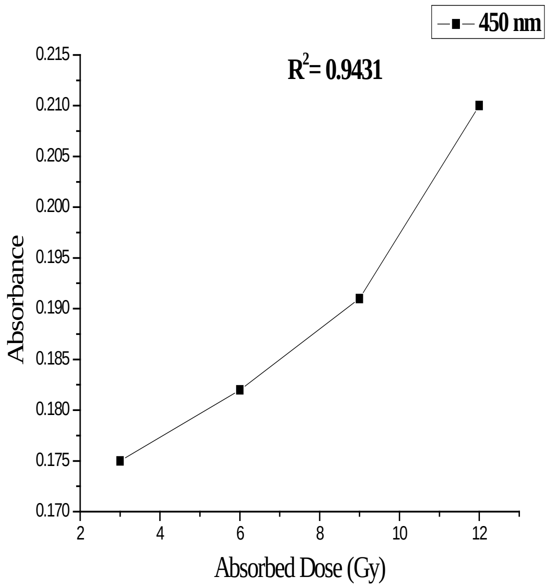

Figure 4. Dose response function at 450nm.

3.2. Linearity and stability

Figure 4 shows the linearity of PAGAT with $AgNO_3$ for 450nm wavelengths. It shows good correlation ($R^2 = 0.9431$). The gel samples with PAGAT and silver nitrate and gelatin with silver nitrate was found to be stable for two weeks when kept in fridge.

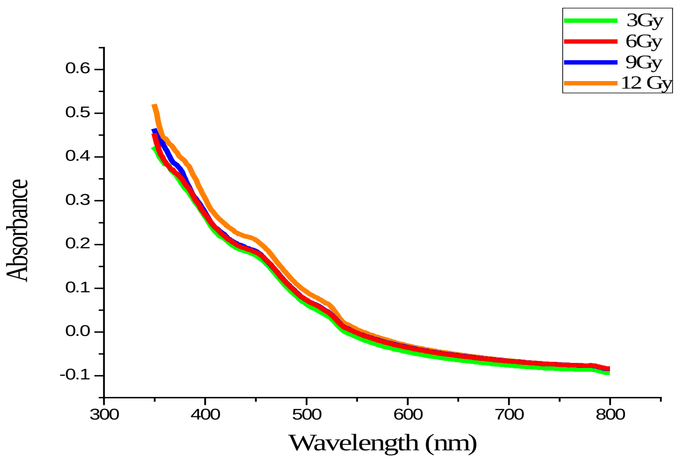

Figure 5. UV-vis spectrum of PAGAT+ $AgNO_3$

4. Conclusion

A new radiochromic gel dosimeter based on PAGAT and silver nitrate was investigated using spectrophotometry in the clinical dose range of 0-12 Gy and the Gamma radiation induces synthesis of Ag nanoparticles in PAGAT gel. The dose response of the dosimeter is linear from 3 to 12 Gy. Future work will be focused on the effects of energy, dose rate and ageing on the response of dosimeter. It also includes working on new additives to improve the radiation sensitivity and stability of the gel.

5. Acknowledgements

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6. References

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