RESEARCH PAPER | Medical Science | Volume : 4 | Issue : 5 | May 2014 | ISSN - 2249-555X

Measurement of Radiation Dose in Radiotherapy using PVA/AgNO3 Composite Film

KEYWORDS: Composites Film, PVA\AgNO3, gamma radiation

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ABSTRACT *The composite films of PVA/AgNO3 have been prepared using casting technique which after irradiation with γ-ray and receiving doses in the range of 1, 2, 4… 12 and 15 Gy) at entrance and exit beam of a phantom, they showed a color changes from white to light yellow, golden, brown and dark brown. The characterization of films by UV-visible spectroscope showed and absorption peaks at 200 and 410 nm, and the absorption peak increase following the increment of applied radiation dose in a linear form based on the following equations: and for entrance and exit dose respectively, where y refers to the absorption in (au) and x refers to the dose in Gray (Gy) with a correlation coefficient of . And the optical density showed great and significant relation between the dose and optical density in a form of linear proportional relation based on the following equations: and for entrance and exit doses respectively, where y refers to optical density and x refers to the applied dose in Gy.*

INTRODUCTION

The effort of radiotherapy equipments manufacture's, Medical physicists, physicians, and radiation technologists have been directed to optimize the radiation therapy dose that should not exceed ± 5% of the prescribed tumor dose [1] or as mention by ICRU, [2] that: the error should not exceeds 3-5%, with critical consideration to the normal tissue dose and the adjacent vital organs.

The utilized tools to measure and assess the dose in radiotherapy are many, such as TLD's which is suitable for in-vivo dosimetry [3-5] tissue equivalent material as Plexiglas [3], polystyrene [6], Aluminum and polytetrafluoroethylene (PTFE) [4] and composite materials (steel , paraffin, Perspex) [6] that having an accuracy of ±2.

One of interesting materials related to such field is the polymer hybridized with metal nanoparticles, in particular silver nanoparticles which exhibit unique optical, electronic, and electrochemical properties that answer many potential applications in optical waveguides, optical switches, molecular identification, oxidative catalysis and antimicrobial effects [7]. These interesting properties are strongly dependent on the particle sizes and shapes and therefore methods of synthesizing silver nanoparticles should be able to control these parameters.

Silver nanoparticles embedded in polymer matrix such as poly (vinyl alcohol) (PVA), poly-methyl-methacrylate (PMMA), and polystyrene have been reported by some authors [8, 9]. Also in this realm Ali et al, [10] studied the effect of electron beam irradiation on the structural properties of Poly (Vinyl Alcohol) formulations with Triphenyl Tetrazolium Chloride Dye (TTC) under various radiation doses.

The irradiation of such composites materials mainly induces various effects in view of chemical modification such as displacing atoms, carbonization, production of free radicals, cross-linking and chain scission that gradually and continuously modify or degrade the structural, morphological, optical and mechanical properties of polymer electrolytes and composition [11- 12]. In this realm Mohammed et al, [13] have showed that there is a linear correlation between the applied dose to PVA\Ag films and the optical density as well as the absorption coefficient. Therefore the trend of this study is to measure the skin dose (surface dose) at entrance and exit points of irradiated phantom and to correlate between the applied dose and the optical density as well as the absorption coefficient in radiotherapy range, as the induced radiation effects in the film composites could be traced by UV-visible spectroscopy and optical densitometer (depending on the color change) [14].

2. Method:

Polyvinyl alcohol PVA (Mw= 8200g/mol), has been dissolved in de-ionized water DIW as 3 wt% under controlled temperature of 80 °C with continuous stirring using magnetic stirrer. Then at the dark room an amount of 0.2 wt% of $AgNO_3$ has been added with continuous stirring for 1 hour. Then the composites solution has been poured in Petri dishes; each has 20 ml and left at true horizontal flat bench at dark room for three days to evaporate the at ambient temperature and the films have been formed by casting. The formed films peeled off, sandwiched between buildup polystyrene, and irradiated (g-radiation from ^{60}Co-machine Equinox) as each 3 films in one envelop. The radiation doses were (0, 2, 4, 6, - 12, and 15 Gy). Then the films were characterized by optical densitometer and UV- visible spectroscope, which their results have been, correlated with the applied radiation doses.

3. Results & Discussion

Figuer1 shows the colour change of the irradiated films receiving different radiation doses (1, 2, 4… 12 and 15 Gy). The color changed from white (un-irradiated film) then to light yellow, golden then to brown and dark brown following the increment of radiation dose. Such color change has been reported by Vladimir et al, [15] and it was due to reduction of Ag^+ by the formed reducing species as hydrated electron (eaq), hydrogen atom radical (H^o) and hydroxyl radical (OH^o). Same study has been reported by Ramnani et al, [16] and Mohammed et al, [14].

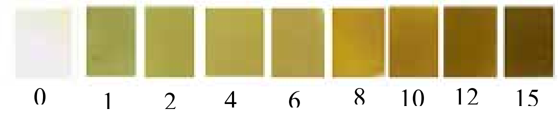

Figure 1 shows the change in the measured parameters for the studied samples due to amount of doses.

Figure 2 shows the UV-spectrum for PVA\AgNO$_3$ films after irradiation with g-radiation receiving same doses in Figure (1). It showed that the irradiated films having absorption band peaking at the wavelengths 200 and 410 nm which are related to criteria of the pure PVA and PVA/AgNO$_3$ respectively. The absorption bands increased following the radiation dose increment, such phenomena has been stated by Mohammed et al, [13] and Ramnani et al, [16]. The absorptions in Figure (1) is related to the applied doses at the entrance of the radiation field, therefore they showed more prominent peaks than in Figure (3) which is related to the absorption at exit site of radiation beam.

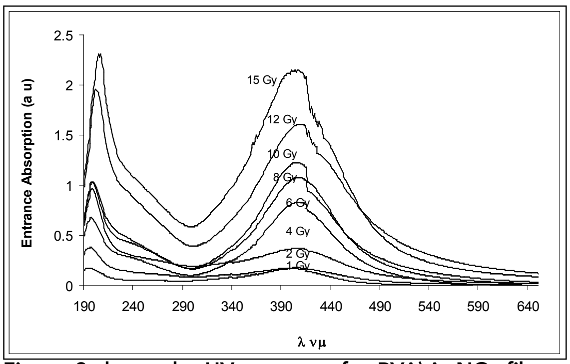

Figure 2 shows the UV-spectrum for PVA\AgNO$_3$ film receiving g-radiation dose 1-15 Gy as entrance applied dose.

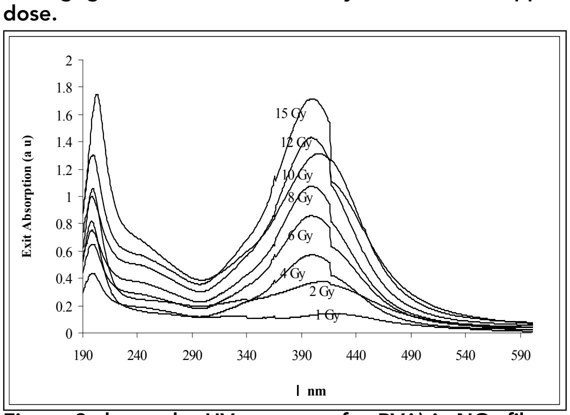

Figure 3 shows the UV-spectrum for PVA\AgNO$_3$ film receiving g-radiation dose 1-15 Gy as exit dose.

Figure 4 shows the correlation between the applied g-radiation doses 1-15 Gy and the absorption coefficient at λ =200 and λ =410 nm for both entrance and exit doses. It showed that the absorption coefficient is increase linearly with increasing of applied dose based in the following equation $y = 0.09x + 0.62 y = 0.09x + 0.62$ and $y = 0.1x + 0.1$ $y = 0.1x + 0.1$ for entrance and exit dose respectively, where y refers to the absorption in (au) and x refers to the dose in Gray (Gy). The correlation coefficient $r^2 = 0.99 r^2 = 0.99$ indicating the sensitivity of the composite film to radiation which in turn showed the possibility of using such types of film as radiation that the composite film can be used as radiation detector after suitable build in an electronic circuit [13]

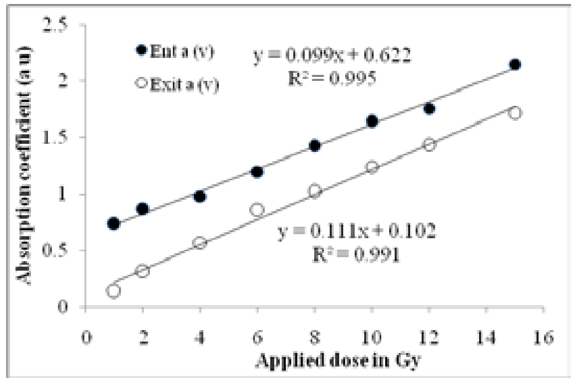

Figure 4 shows the correlation between the applied g-radiation doses 1-15 Gy and the absorption coefficient at entrance and exit doses.

Figure 5 shows the correlation between dose in Gy and the relevant optical density in a u, for entrance and exit doses in the range of 1-15 Gy at a peak of 200 and 410 nm. It shows that there is a linear proportional correlation between the two parameters (dose in Gy and optical density) in the absorption band of 200 and 410 nm, however the relation of absorption in the range of 410 nm is strong as: $r^2 = 0.98 r^2 = 0.98$, for entrance and exit doses ; which ascribed to the sensitivity of the silver to radiation and further more encouraging the application of PVA/Ag film as a radiation detector or monitoring based on optical density change. The correlation could be fitted to the equation of the following form: $y = 0.04x + 0.12$ $y = 0.04x + 0.12$ and $y = 0.03x + 0.99 y = 0.03x + 0.99$ for entrance and exit doses respectively, where y refers to optical density and x refers to the applied dose in Gy [13].

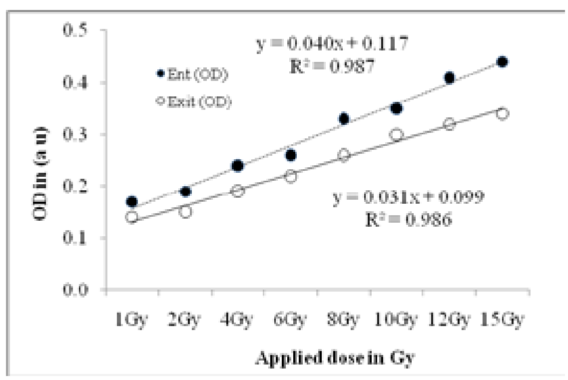

Figure 5 shows the correlation between dose in Gy and the relevant optical density in (a. u).

Conclusions:

The results of this work showed that the PVA/AgNO$_3$ composite film can be used as radiation detector or radiation monitor successfully based on the strong correlation coefficient (R^2 = 0.98) and could be optimized and calibrated depending on the Thermo-luminescence detectors (TLD)

Volume : 4 | Issue : 5 | May 2014 | ISSN - 2249-555X

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