Development of a PVA-based Fricke gel dosimeter

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Introduction

Ferrous sulphate infused (Fricke) gels based on various matrices have been studied for decades as 3D dosimeters for conformal radiotherapy. We here present the development and characterization of a new gel dosimeter based on a polyvinyl alcohol (PVA) matrix. The gold standard for gel dosimetry so far have been gels made with natural polymers (porcine skin or agarose). Compared to them, PVA has a higher chemical purity and can yeld hydrogels with different degrees of crosslinking, thus helping to solve the problems related to self-oxidation and diffusion of ions, the main drawbacks of this technique so far.

Developed dosimeter composition

The objective of this work is to develop a gel dosimeter made by a PVA polymer crosslinked with glutaraldehyde (GTA). We tested different compositions, studying with a rheometer the influence of GTA and temperature over gelation time (fig.1). The initial absorbance of the gel was found to be strongly dependent on the amount of GTA (fig.2). All that considered, tab.1 shows the PVA-based gel composition that we decided to study, compared to the gelatine gel used up to now.

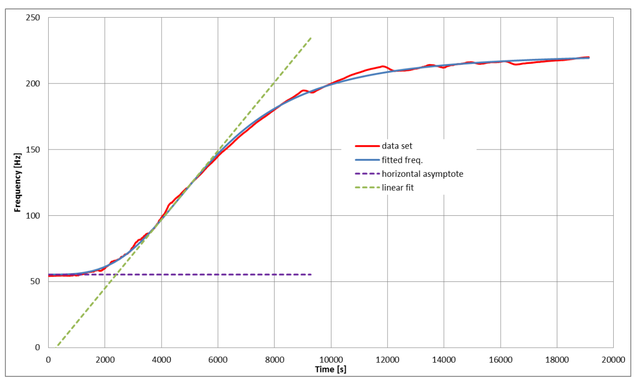

Fig.1 Gelation time

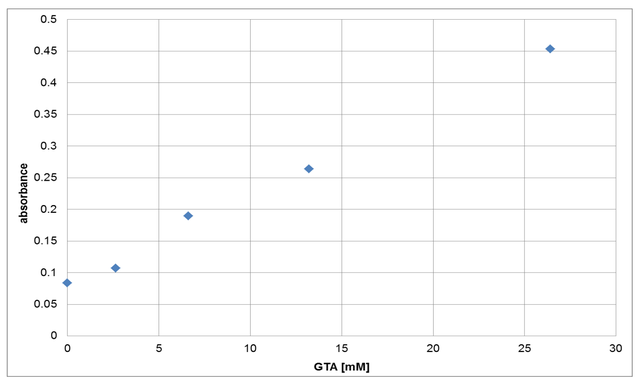

Fig.2 Initial absorbance vs. GTA

Matrix	H_2SO_4	Fe^{2+}	XO	GTA
PVA 10% w/v	25mM	0.5mM	0.165mM	6.6mM
Gelatine 3% w/v	25mM	0.5mM	0.165mM	-

Tab. 1 Gel compositions

Dosimeter sensitivity and diffusion properties

The sensitivity of the PVA gel is almost the same as with gelatine, being equal to 0.073 Gy^{-1}. PVA dosimeter, on the other hand, has a lower minimum detectable dose, 0.1 Gy instead of 0.6 Gy as with gelatine. A comparison between the diffusion coefficients (D) of PVA and gelatine gel was made by irradiating cuvettes of both samples partially covered with a lead shield (fig.4). Absorbance-position profiles along the cuvettes axis (fig.5) were collected every 3 hours with a spectrophotometer equipped with a moving tray. This allowed us to measure the blurring of the irradiated edge with time.

The obtained profiles were fitted wit an inverse square function, confirming the existence of a direct relationship between the variation of the curvature parameter *n* with time and the diffusion coefficient D, as previously found by other researchers. With this method we found a diffusion coefficient of our PVA based gel equal to 0.23 mm^2/h, a half of that of gelatine gel that is equal to 0.56 mm^2/h.

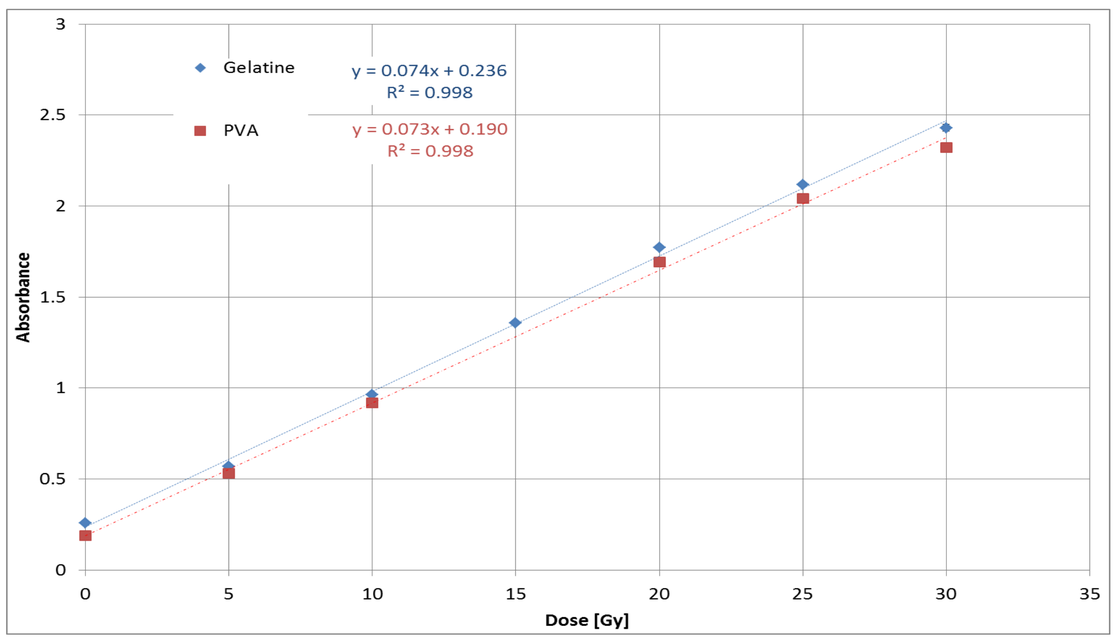

Fig.3 Comparison between sensitivity of PVA and gelatine gel

Results and future works

PVA-based gel dosimeters have shown good qualities, having a sensitivity comparable to that of gelatine based dosimeters and a 50% lower diffusion coefficient. Therefore, PVA crosslinked with glutaraldehyde presents the potential to replace the most common polymers (porcine skin and agarose gelatine) as host matrix for gel dosimeters.

In our future works we will focus on developing new formulations with the purpose to further reduce the diffusion coefficient and the oxidation rate.

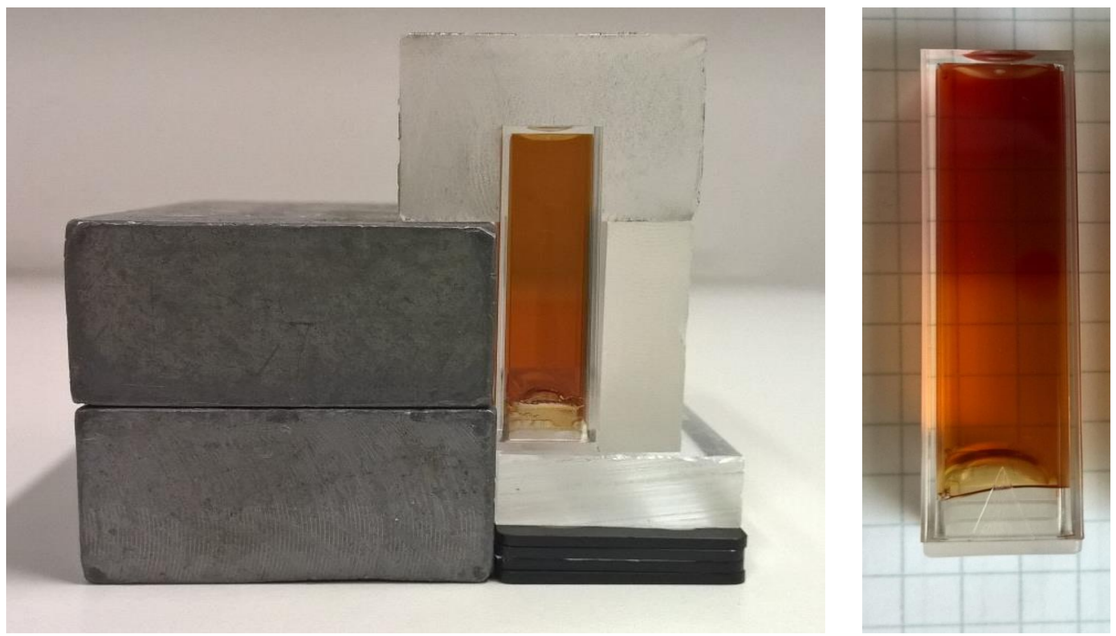

Fig.4 Setup for diffusion measurements

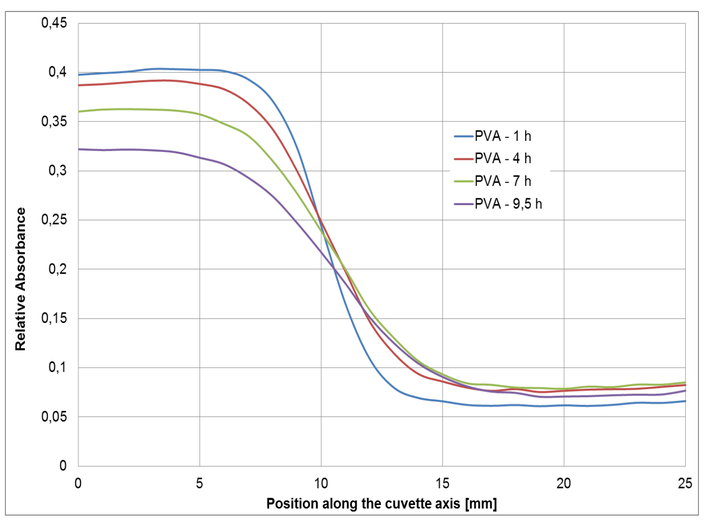

Fig.5 Absorbance-position profiles

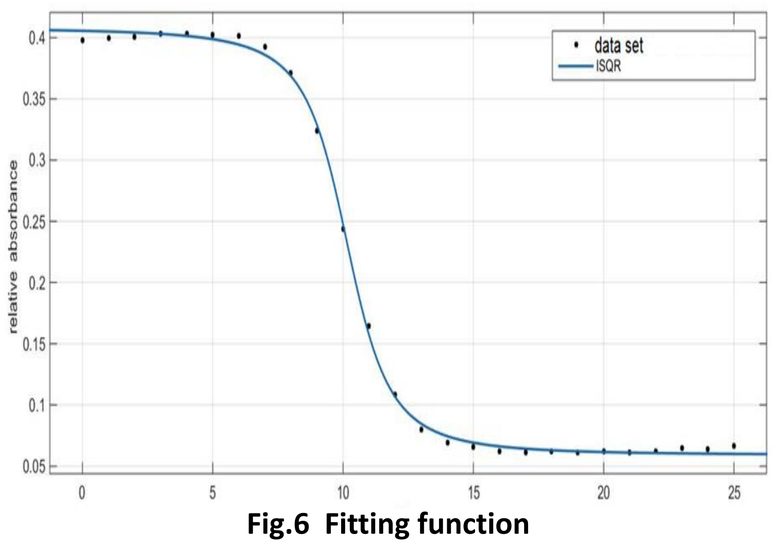

Fig.6 Fitting function

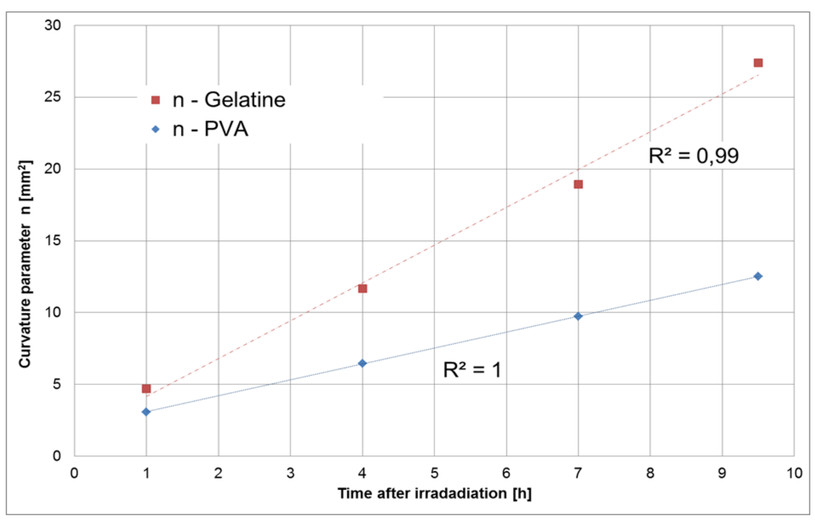

Fig.7 Curvature parameter n versus time