Reproducibility and Signal Response Linearity of Alanine Gel Dosimeter

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Abstract. Gel Dosimetry has been studied mainly for medical applications, because it presents signal response in the dose range used in radiotherapy treatments and it can be applied for three dimensional dosimetry.Alanine Gel Dosimeter is a new gel material developed at IPEN that presents significant improvement on previous alanine systems developed by Costa (1994). The DL-Alanine ($C_3H_7NO_2$) is an amino acid tissue equivalent that improves the production of ferric ions in the solution. These ferric ions concentration can be measured by spectrophometry technique.This work aims to study the reproducibility of the alanine gel solutions and the signal response as a function of gamma radiation dose, considering that these two properties are very important for characterizing and standardizing any dosimeter.

KEYWORDS: Alanine Gel dosimeter; Chemistry Dosimetry; ^{60}Co Beam.

1. Introduction

Nowadays, gel dosimetry has become an useful tool for the verification of radiation treatments in water-equivalent tissues, because it is of crucial importance to thoroughly determine the absorbed dose in them. Gore et al published the first work of Gel Dosimetry area in 1984 [1], when he proposed combining the system with magnetic resonance imaging to make possible three-dimensional radiation dosimetry. The stability of Fricke solution was a big problem, so Gore incorporated the Fricke solution into a gel matrix solving this problem. The modern gel dosimetry was born through the development of this combination [2].

The main dosimetric properties that a material has to present are response signal linearity, stability and reproducibility. The influences of external factors in radiation dosimetry have also to be studied. The main factors are energetic dependence response, environmental conditions and dose rate dependence [3].

Considering this factors, this work aims to analyze the reproducibility and signal response dose linearity of the Alanine dosimeter developed by Mizuno (2007) [4]. Alanine is an amino acid tissue equivalent that improves the production of ferric ions in the solution. This new gel material presents significant improvement on previous alanine systems developed by Costa (1994) [5] using spectrophotometric and electronic paramagmetic resonance evaluation techniques, and can be useful to three-dimensional dose evaluation using magnetic resonance imaging.

The study of dosimetric system is based on the difference of concentration of ferrous (Fe^{2+}) and ferric (Fe^{3+}) ions induced by the radiation in the solution, and it is possible to measure by means of spectrophometry technique. The DL-Alanine present in this system improves the production of ferric ions, which increases the signal response in comparison to the Fricke gel dosimeter.

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2. Materials and Methods

2.1 Alanine gel solution

The dosimetric system was prepared following the method described by Mizuno (2007) using 300 Bloom gelatin. The table 1 shows the chemical composition of the studied solution.

Table 1: Chemical composition of Alanine gel solution.

Compound	C (mol/L)
Ferrous Ammonium Sulfate	0.001
Xylenol	0.0002
Sulfuric Acid	0.2375
DL-Alanine	0.6735
Tri-distilled water	5.55
Gelatin (300 Bloom)	10 % of the tri- distilled water volume

2.2 Gamma Irradiation

Different batches of Alanine solution were prepared and maintained at 6ºC during 12 h to solidification. Before irradiation the samples were maintained during 1 h at room temperature (~20ºC). The gamma irradiations were performed in air and electronic equilibrium conditions with doses between 0.5 and 50 Gy. Each batch is composed of 30 cuvettes filled with alanine Gel, separated in 6 groups. Each group was irradiated with different doses between 5 and 45 Gy except one that was not irradiated, considered as background.

2.3 Spectrophotometric evaluation

The technique spectrophotometry using a Shimadzu UV-2101 PC can be used for measuring the ferric ions concentration (Fe^{3+}) induced by radiation in the Alanine gel solution. According to Gore (1984), the absorbed dose is proportional to the variation on the optical density. But in general, it is more practical use a calibration curve to determine the relationship between absorbed dose and optical density, because each batch presents a different chemical efficiency [6].

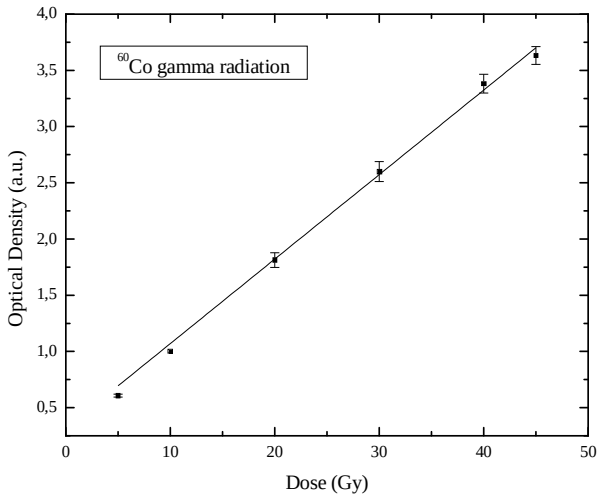
The measures were always performed 1 h after irradiation. Each presented value is the average of 6 measures.

3. Results and Discussion

3.1 Dose response

Fig. 1 shows the Alanine gel dose response curve. It can be observed that in the studied dose range, between 5 and 45 Gy, the signal response presents a linear behavior. According to Galante the Fricke gel solution developed at IPEN using 300 Bloom gelatine presents linear behavior between 5 and 25 Gy [7].

Figure 1: Alanine gel dose response curve to ^{60}Co gamma radiation.

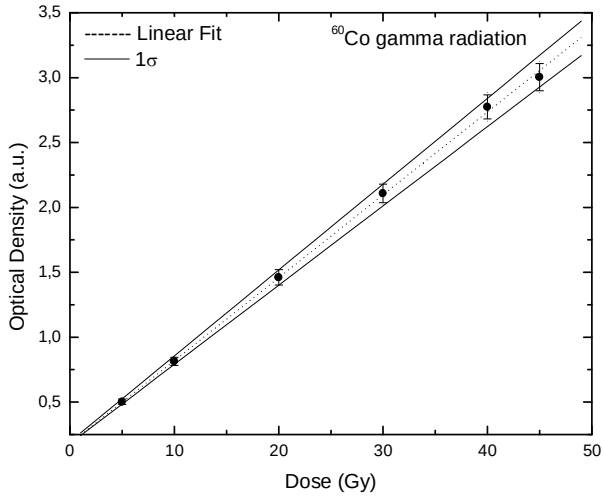


3.2 Intra-batch and inter-batches reproducibility

The intra-batch Alanine gel solution signal reproducibility to ^{60}Co gamma radiation was evaluated taking the standard deviation (1σ) of the mean of 6 different samples obtained from the same batch irradiated with doses between 5 and 45 Gy. The optical response presents intra-batch reproducibility better than 4%.

The inter-batches reproducibility was evaluated taking the standard deviation (1σ) of the mean of 6 different solution batches irradiated with doses between 5 and 45 Gy. The optical response presents also inter-batches reproducibility better than 4%.

Figure 2: Inter-batch reproducibility of Alanine gel solution to ^{60}Co gamma radiation.



In both cases the reproducibility of Alanine gel solution is better than 4%. According to Cavinato (2007) the Fricke gel solution developed at IPEN presents inter-batch reproducibility better 10 % [8].

4. Conclusion

The obtained results indicate that Alanine gel dosimeter presents good performance in gamma radiation field and can be used as an alternative dosimetric material in the dose range studied. The gel solution can be useful as dosimeter in the radiotherapy area using MRI technique for 3D dose distribution evaluation.

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