DEPENDENCE OF ALANINE GEL DOSIMETER RESPONSE AS A FUNCTION OF PHOTON CLINICAL BEAMS DOSE RATE

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ABSTRACT

Gel dosimetry is a new area developed by Gore, it is very useful to application in radiotherapy treatments because using Magnetic Resonance Imaging as evaluation technique it is possible evaluate three dimensional absorbed dose distribution. The measure technique is based on difference of ferrous (Fe^{2+}) and ferric (Fe^{3+}) ions concentration that can be measured also by spectrophotometry technique. The Alanine gel dosimeter was developed at IPEN. The alanine is an amino acid and tissue equivalent material, that presents significant improvement on previous alanine dosimetry systems. The addition of Alanine increases the production of ferric ions in the solution. This work aims to study the dose rate dependence of photon clinical beams radiation on the alanine gel dosimeter optical response, as well as the response repeatability and gel production reproducibility, since this property is very important for characterization and standardization of any dosimeter.

1. INTRODUCTION

Gel Dosimetry area was developed in 1984 by Gore et al [1], that published the first work in this area. The stability of Fricke solution was a big problem, so Gore incorporated the Fricke solution into a gel matrix solving this problem and proposed combining the gel system with magnetic resonance imaging to make possible three-dimensional radiation dosimetry, considering that in radiotherapy area is very important to determine the hot and cold spots in volume, in other worlds, the three-dimensional mapping of the absorbed dose distribution in the volume of interest has become a very important tool to check if the radiation treatment was applied properly. Therewith gel dosimetry become possible its application in three dimensional dose distribution evaluations[2].

Alanine gel dosimeter was developed by Mizuno in 2006 at IPEN [3]. Alanine is an amino acid tissue equivalent that improves the production of ferric ions in the solution, in other worlds, alanine increases the ionization power in this solution. Therewith alanine system presents significant improvement on previous Alanine solution system developed by Costa [4].

In this work the dose rate dependence of optical response of alanine gel solution in function of photons clinical beams was evaluated, as well as the response repeatability and gel

production reproducibility, because this dosimetric properties are of crucial importance for characterizing and standardizing a dosimetric system [5].

2. MATERIAL AND METHODS

2.1. Alanine gel solution

The dosimetric system was prepared following the method described by Mizuno (2007) using 300 Bloom gelatin, but in case the solution was heating until 45º C. The gel solutions were conditioned in cuvettes with dimensions 1 cm x 1 cm x 4.6 cm and optical path of 10^{-2} m, which can be observed in figure 1, and maintained at low temperature during 12 h to solidification.

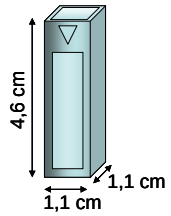

Figure 1. Cuvettes dimensions.

Before irradiation the samples were maintained during 1 h at room temperature. 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 Acrylic Support

For guaranteeing the desired depth and backscattering conditions in photon clinical beams irradiations a specially designed acrylic support was developed at IPEN, in which the samples can be always sandwiched between solid water plates RW3, that can be positioned on and under the acrylic support. It can be seen in Figure 2.

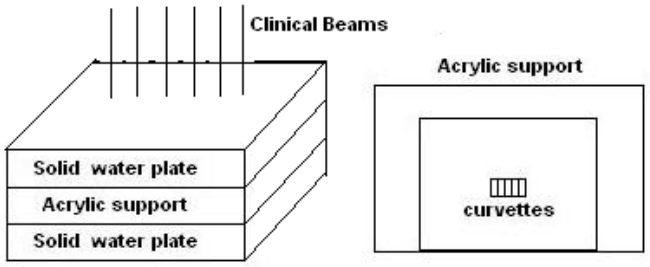

Figure 2. Irradiation set up to photons electrons irradiations.

2.3 Spectrophotometric Evaluation

The photon irradiations were performed using a Varian 2100 C Medical Linear Accelerator of the Radiotherapy Department of the Hospital das Clínicas of the University of Sao Paulo with dose of 5 Gy at maximum dose dept (1.5 cm), radiation field of 10 x 10 cm^2, energy photons of 6 MeV and dose rates between 120 and 360 Gy/h.

Each batch is composed of 24 cuvettes filled with alanine Gel, separated in 6 groups; each group was irradiated with different dose rate, except one that was not irradiated, considered as background.

2.4 Spectrophotometric Evaluation

The optical response (absorbance) was measured using a Shimadzu UV-2101 PC spectrophotometer applying the following set up parameters presented at table 2:

Table 2. Spectrophotometer reading set up parameters.

Parameters	Value
Wavelength range (nm)	400 - 700
Light source	Tungsten and Deuterium
Slit width (nm)	2
Absorbance (%)	-9.999 - +9.999
Transmittance (%)	-999.9 - +999.9
Scan speed (nm/min)	1600 (fast and 2nm interval)
Precision (nm)	0.1

3. RESULTS AND DISCUSSION

The gel production reproducibility of different gel solutions prepared during a period of six months was better than ± 4%.
The repeatability of dose response obtained was better than ± 4%.
According to figure 3, the alanine gel solution presents a very low dose rate dependence response, better than ±1,9 % (1σ) between 120 and 360 Gy/h, which indicates that the optical signal response (absorbance) can be considered independent of the dose rate.

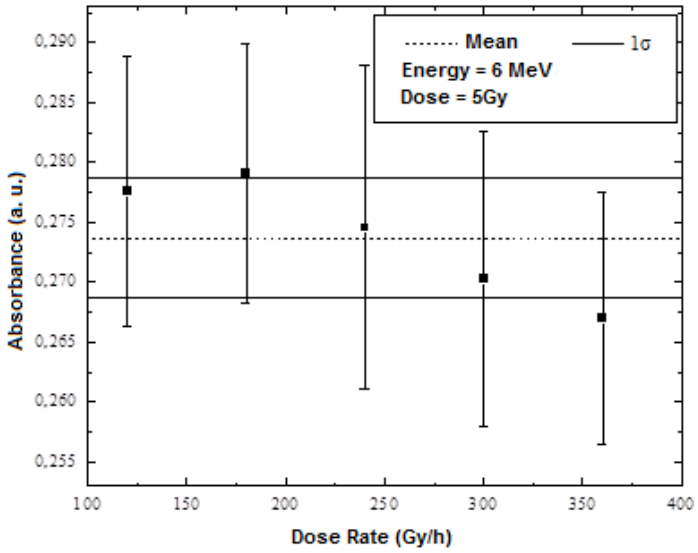

Figure 3. Dose rate response of alanine gel solution to 6 MeV photon clinical beams radiation.

3. CONCLUSIONS

The obtained results indicate that the reproducibility and repeatability of the gel solution is acceptable for clinical dosimetry and that it is possible to evaluate the absorbed doses for different dose rates for photon clinical beams irradiation without application of correction factors.
The Alanine gel dosimeter presents good performance and can be useful as alternative dosimeter in the radiotherapy area using MRI technique for 3D dose distribution evaluation.

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