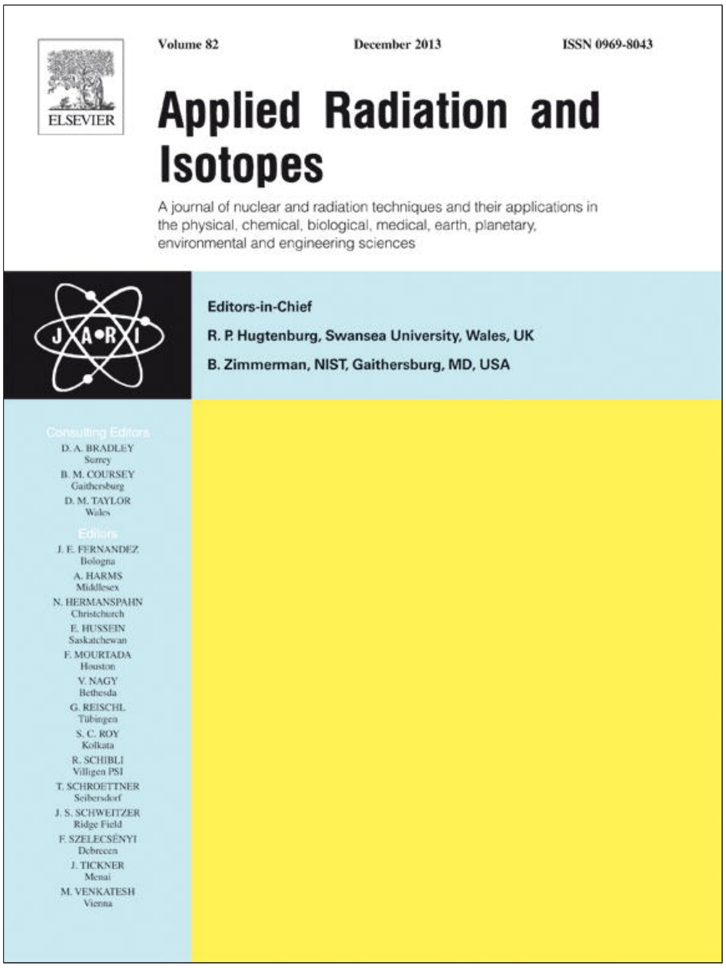
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Technical note

Fricke dosimeter gel measurements of the profiles of shielded fields

Luis F. Pirani [a], Marcos V. Moreira [b], Jhonatha J.L. Costa [c], Lucas N. Oliveira [c,d,*], Linda V.E. Caldas [d], Adelaide de Almeida [e]

[a] Instituto Nacional do Câncer—INCA, Rio de Janeiro-RJ, Brazil
[b] Instituto de Radiotarapia e Megavoltagem, Ribeirão Preto-SP, Brazil
[c] Instituto Federal de Educação, Ciência e Tecnologia de Goiás, Inhumas-GO, Brazil
[d] Instituto de Pesquisas Energéticas e Nucleares—IPEN, São Paulo-SP, Brazil
[e] Universidade de São Paulo-USP, Ribeirão Preto-SP, Brazil

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ABSTRACT

In radiation therapy, the shielding of normal tissue can be made using Cerrobend® blocks or a multileaf collimator. In this work, profiles of shielded fields collimated by Cerrobend blocks were obtained through the Fricke Xylenol Gel (FXG) dosimeter irradiated with 6 MV photon beams. The results show that the FXG system can be used in profile measurements of small fields in radiotherapy.

1. Introduction

In radiation therapy, dose distribution is required for irregular configuration fields for photon beams. Consequently, using protection to shield regions in which structures should be preserved (Johns and Cunningham, 1983; Khan., 1993) has become necessary for radiotherapeutic treatments. The planning system uses algorithms that make corrections for the presence of these shielded fields, and the IAEA protocol (IAEA, 2004; International Commission on Radiation Units and Measurements ICRU) 1987) recommends that tests be made for validation of the planning. As a result, the irradiation of cancerous regions and protection of normal tissues is the goal in radiation therapy, and this protection takes place by shielding the radiation field through multileaf collimators or Cerrobend. These irregular, shielded, small and large fields are formed in order to ensure the treatment quality. Cerrobend results blinded accurately around 3% of the primary radiation beam intensity transmittance. Its simple fabrication can be established in most radiation therapy departments (Ezzell et al., 1987; Famiglietti et al., 1990; Muller-Runkel et al., 1985).

This work aims at obtaining profiles of shielded fields through the Fricke Xylenol Gel (FXG) dosimeter. The development and characteristics of our innovations to the FXG and the reading system are described elsewhere (Bero, 1999; Pirani et al., 2009; Bero et al., 2000). The FXG presents good sensitivity for low and high absorbed doses, and can be used for radiotherapeutic dosimetry as a broad linear dependence to the absorbed dose from 0.5 to 30 Gy for gamma and X ray photons, atomic effective number of 7.75 and density of 1.139 g/cm^3, near to 7.64 and 1.040 g/cm^3, respectively, for soft tissue. The system FXG+reader is of low cost, and readings are taken at 585 nm (Oliveira et al., 2009; Caldeira et al., 2007).

In radiotherapy, one of its main objectives is to control the dose administrated to the patient. Therefore, an accurate and precise dosimetry is necessary so that the prescribed absorbed dose can be administrated to the patient. The Fricke Xylenol Gel (FXG) dosimetry has shown interesting results applied to radiotherapy through dosimetric parameters studies, as measures of small irradiation fields, and a good agreement for these fields in comparison to other dosimeters such as ionization chamber, film and TLD (Calcina et al., 2007; Oliveira et al., 2007).

In the present work, for the first time, the profiles of shielded fields were established for the FXG for several diameters of blocks and irregular forms.

2. Materials and method

The FXG dosimeters were prepared with the following concentrations of reagents: 124.38 mM gelatin 300 Bloom swine skin, 25 mM sulfuric acid, 0.5 mM ferrous sulfate, 0.1 mM xylenol orange and 96% of the gel volume consists of water Milli-Q. Its preparation and applications are found in the literature (Sampaio et al., 2013a; Sampaio et al., 2013b). The FXG dosimeter was inserted into cuvettes with dimensions of 30 × 30 × 1 cm^3,

* Corresponding author. Tel.: +55 62 3514 9500; fax: +55 62 3514 9595.
E-mail addresses: lucas@ifg.edu.br (L.F. Pirani), aqueleemail2000@yahoo.com.br (L.N. Oliveira).

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irradiated and read with a spectrophotometer (Vary-Varian/Ultro-pec2100/79500) suitable for high-resolution (1 mm diameter aperture beam of 585 nm).

In this work, FXG dosimeters were irradiated with a linear accelerator (Siemens/Mevatron/6MD), 6 MV photon beams, surface source distance of 100 cm, depth of maximum dose equal to 1.5 cm, radiation doses of 10 Gy and a square field size of 10×10 cm^2. The readings were normalized to the maximum reading on the field of interest.

The experimental arrangement is shown in Fig. 1, the central axis of the beams were centered in squared cylindrical shields with external diameter of 5 cm and central circular cylindrical holes with diameters of 0.3, 0.6, 2 and 3 cm (Fig. 2). There was also a screening of irregular size with the same characteristics. All these shields are 7.5 cm in size (10ª tenth-value layer) made of Cerrobend®.

The beam profiles were obtained through circular small fields (Cerrobend blocks) with different collimator dimensions. FXG optical density measurements were made along the higher dimension of the cuvette The beam profile values were obtained from the averaged values from three measurements and normalized with the radiation field center value (maximum absorbed dose value), for all field sizes, according to the following Eq. (1):

$$BP = \frac{D_i}{D_c} \quad (1)$$

where D_i and D_c are, respectively, the absorbed doses along the field and at the buildup position in the central axis.

The field penumbra width was calculated, which represented the average of the normal separations between 20% and 80% isodose lines along the prescription outline. Second, the ratio of areas covered by the 90% and 20% isodose lines, A90/20, was determined, using FXG dosimeters.

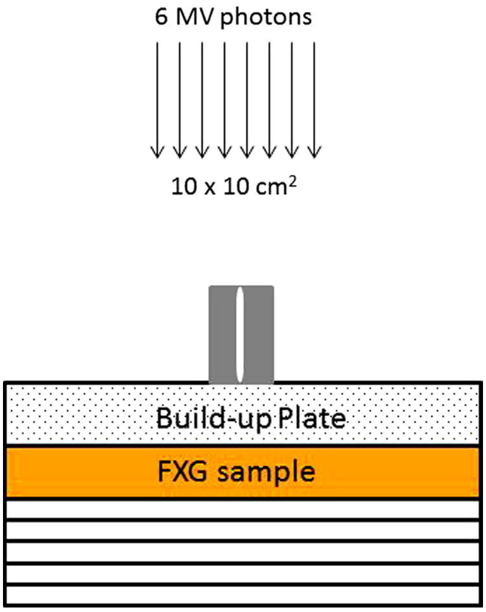

Fig. 1. Experimental scheme for irradiation of samples in a field of 10×10 cm^2 with an absorbed dose of 10 Gy.

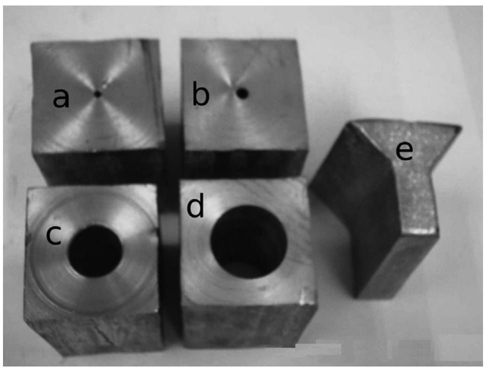

Fig. 2. Photo of the Cerrobend® blocks with 7.5 cm (10ª tenth-value layer) made of made to block the radiation field. Blocks have surface area of 5cm^2 and diameters of (a) 0.3, (b)0.6, (c) 2, (d) 3cm, and (e) an irregular shape, for medical routines.

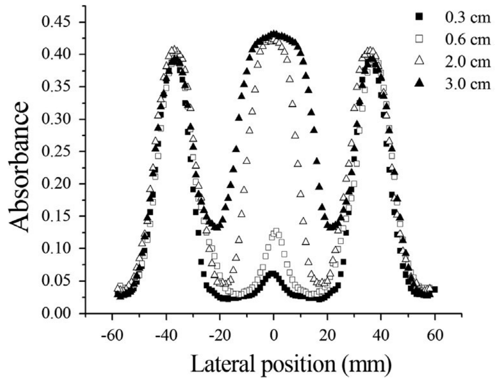

Fig. 3. Beam field profiles for shielding cylindrical orifices of 0.3, 0.6, 2, and 3 cm in diameter.

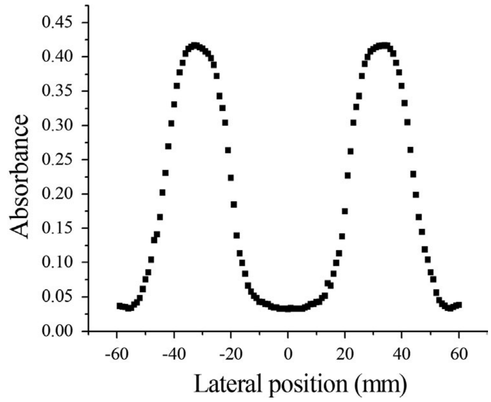

Fig. 4. Beam field profiles for irregular shields.

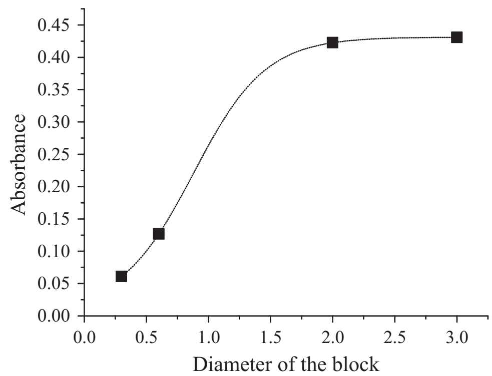

Fig. 5. Absorbance *versus* hole diameters of Cerrobend® blocks.

3. Results

In Figs. 3 and 4, the shielded profiles, obtained from 6 MV photon beam irradiations, are shown for FXG sample.

In Fig. 3, the penumbra width was the same for all circular beam field profiles, with the value of 0.3 mm. The ratio A90/A20, as expected, was gradually increased according to the size of the hole, thus obtaining: 12.42, 13.01, 69.03, and 77.08 respectively for 0.3, 0.6, 2 and 3 cm circular diameters. This result is in accordance with Fig. 5.

In Fig. 4, the penumbra width obtained was 0.4 mm; this result is within a tolerance of 1.3 cm established in the literature for beams of photons (Sharma et al., 1995).

Fig. 5 shows that for small fields, the diameter increases as the contribution to the reading increases reaching a plateau for larger fields.

4. Conclusions

For the analysis the results obtained are as follows: (1) The increase of scattered radiation increases with the diameter of the holes, (2) the effect of scattered radiation was observed less strongly by increasing the hole diameters, (3) adding the holes blocks the beam, the peak absorption tends to decrease, and (4) FXG may be useful irregular shields. This work shows that the FXG dosimeter can be applied for evaluating profiles of shielded fields, solving even very small irradiation fields.

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