Applied Radiation and Isotopes 67 (2009) S195–S198

Contents lists available at ScienceDirect

Applied Radiation and Isotopes

journal homepage: www.elsevier.com/locate/apradiso

In-phantom dose imaging with polymer gel layer dosimeters

E. Vanossi [a,b], M. Carrara [c], G. Gambarini [d,b,*], A. Negri [d], M. Mariani [a]

[a] Department of Energy, Nuclear Engineering Division, Polytechnic of Milan, Via Ponzio 34/3, 20133 Milano, Italy
[b] INFN Milan, Via Celoria 16, 20133 Milano, Italy
[c] Fondazione IRCCS "Istituto Nazionale Tumori", Via Venezian 1, 20133 Milano, Italy
[d] Department of Physics, University of Milan, Via Celoria 16, 20133 Milano, Italy

ARTICLE INFO

Keywords:
BNCT dosimetry
Gel dosimetry
Polymer gel
Dose imaging

ABSTRACT

Gel dosimeters in form of layers have shown noticeable potentiality for in-phantom dose profiling and imaging in BNCT neutron fields. Such dosimeters give the possibility of achieving spatial dose distributions of each dose contribution in neutron fields. The various dose components are separated by means of pixel-to-pixel manipulations of pairs of images acquired with gel dosimeters having different isotopic compositions. The reliability of polymer-gel-layer dosimeters (PGLD) for BNCT has been studied and their utilisation limits have been inspected.

© 2009 Elsevier Ltd. All rights reserved.

1. Introduction

The method for spatial determination of absorbed doses in thermal or epithermal neutron fields, based on gel dosimeters in form of layers, has revealed to be very convenient. In fact, by using gel layer dosimeters it is possible, by means of a properly studied procedure, to obtain the spatial dose distribution of each dose contribution in thermal or epithermal neutron fields (photon and charged particle doses).

BNCT dosimetry using Fricke-xylenol-orange-infused gel dosimeters has been widely studied and experimented, giving reliable results. Polymer-gel-layer dosimeters (PGLD), in which a polymerisation process appears as a consequence of absorbed dose, have been recently tested, because of their characteristic absence of diffusion. In fact, due to the diffusion of ferric ions, Fricke-gel dosimeters require prompt analysis after exposure to avoid loss of spatial information. In this work the recent results of a study about the reliability of polymer gel in BNCT dosimetry are discussed.

In tissue exposed in the thermal column of a nuclear reactor, after injection of the boron carrier, the absorbed dose results from three main contributions: the therapeutic dose due to alpha and lithium particles released in the reaction of thermal neutrons with ^{10}B (^{10}B(n,α)^{7}Li), the dose from protons due to the reaction of thermal neutrons with nitrogen (^{14}N(n,p)^{14}C) and the gamma dose from the reaction of thermal neutrons with hydrogen (^{1}H(n,γ)^{2}H and background, if not negligible). The fast neutron dose mainly due to recoil protons from elastic scattering of fast neutrons with hydrogen nuclei is negligible in reactor thermal columns.

2. Materials and methods

The experiments were carried out by exposing a phantom containing the dosimeters in the thermal column of the TRIGA MARK II reactor of the University of Pavia. This is the reactor in which BNCT had been successfully applied to treat multiple and diffused liver metastases by means of extracorporeal exposure (Pinelli et al., 2002).

The aim of this work is the study of the feasibility of utilising gel dosimeters. To this purpose, a simple shape (cylindrical) was chosen for the phantom, consisting of a tissue equivalent (TE) material with a total mass similar to that of a liver.

Polymer gel dosimeters in form of layers were used to measure the spatial distribution of the absorbed dose in a phantom irradiated in the thermal column.

The dosimeters were rectangular ($12 \times 6\,\mathrm{cm}^2$) and had a thickness of 3 mm. The layer holders were composed of a rectangular frame between two transparent sheets in order to allow the optical analysis of light transmittance. In Fig. 1 some polymer gel layers after irradiation are shown.

The polymer gel dosimeter PAG (Polymer Acrylamide Gelatine), suitably synthesised in the laboratory, was used for the measurements shown here. The samples were always irradiated one day after the preparation. The gel composition is the same utilised by others (Baldock et al., 1998) with a variation in the amount of the gelling agent that was lowered to make the compound more fluid to facilitate the gel introduction in the holder by means of a siring, through apposite holes in the frame.

* Corresponding author. Dipartimento di Fisica dell'Università e INFN – Sezione di Milano, Via Celoria 16, 20133 Milano, Italy. Tel: +39 02 50317243; fax: +39 02 50317618.
E-mail address: grazia.gambarini@mi.infn.it (G. Gambarini).

0969-8043/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.apradiso.2009.03.048

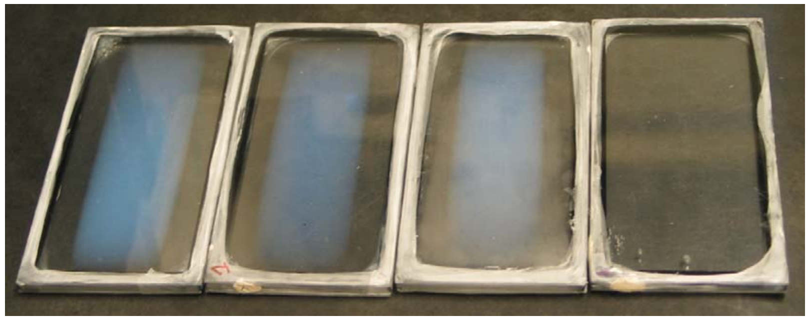

Fig. 1. Layers of polymer gel after irradiation.

Fig. 2. Phantom utilised for the irradiation of gel dosimeter layers.

The gel dosimeters are prepared with the following chemical reagents: gelatine powder as gelling agent, acrylamide and N,N' methylene-bisacrylamide as monomers, tetrakis (hydroxymethyl) phosphonium chloride (THP) as antioxidant and highly purified and deionised water. The amount of each compound was the same reported in previous papers (Mariani et al., 2007; Vanossi et al., 2008), reporting the results of the first studies about the feasibility of performing BNCT dosimetry with PGLD. The method had been improved for both the dosimeter preparation protocols and the image elaboration software.

Couples of gel dosimeters were put in a cylindrical phantom and exposed in the thermal column of the nuclear reactor TRIGA MARK II of Pavia. The phantom, shown in Fig. 2, was composed of two polyethylene shells (1 mm thick) having the shape of about half-cylinder, filled with a tissue-equivalent gel obtained by dissolving in purified and deionised water the gelling agent agar in the amount of 4% of the final weight. The two parts were assembled around the dosimeters in order to finally obtain a TE cylindrical phantom with the dosimeters in the central plane. The so obtained phantom had a height of 11 cm and a diameter of 12 cm.

In order to determine the gamma dose and the dose due to the charged particles emitted during the reactions of neutrons with ^{10}B, couples of gel dosimeters were prepared, one having the standard chemical composition and the other containing also a

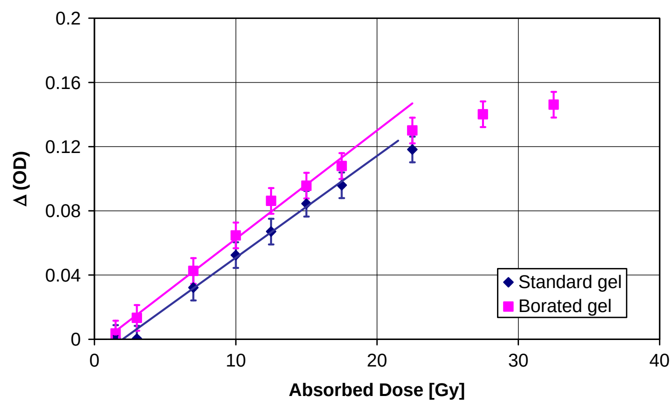

Fig. 3. Calibration curves of standard (◆) and ^{10}B-added (■) polymer gel dosimeters.

40 ppm of ^{10}B. The neutron transport is determined by the whole phantom and a change in the isotopic content of the dosimeters that are layers having a thickness of only 3 mm, do not give measurable differences.

The method for separating the various dose contributions developed using Fricke-gel dosimeters (Gambarini et al., 2004) was applied to determine the different contributions of the absorbed dose. The polymer gel dosimeters were optically analysed by imaging the samples placed on a plane light source by means of a CCD camera. The difference $\Delta(OD)$ of optical density detected before and after irradiation is proportional to the absorbed dose that was therefore evaluated by means of dosimeter calibrations. The algorithms for the separation of the dose contributions take into account that the sensitivity of the dosimeters changes with LET of the radiation. For the sensitivity to the products of the reactions with ^{10}B the value 0.41 was assumed (Gambarini et al., 2002).

Gel dosimeter calibration was performed for each gel preparation. To this aim some dosimeters of each group were irradiated at different doses with a calibrated ^{137}Cs source.

3. Results

An example of the gel calibration is shown in Fig. 3 where the calibration curves for a standard polymer gel and a gel added with ^{10}B are reported.

Some exposures of the cylindrical phantom containing couples of polymer gel dosimeters (standard and ^{10}B-added) in the thermal column of TRIGA MARK II reactor were carried out. From the light-transmittance images of the two dosimeters by means of pixel-to-pixel elaborations using the proper algorithm, both boron

Download English Version:

https://daneshyari.com/en/article/1876923

Download Persian Version:

https://daneshyari.com/article/1876923

Daneshyari.com