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LOW ENERGY X-RAYS TL DEPENDENCE OF CaSO4:Dy DOSIMETER BADGE

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ABSTRACT

A thermoluminescence dosimeter (TLD) using calcium sulfate doped with dysprosium ($CaSO_4$:Dy) produced at IPEN is used for dose evaluation in environmental and personal monitoring. Despite its energy dependence, $CaSO_4$ shows high sensitivity is that a distinct advantage. The dosimetry system consists of a polyethylene badge with three discs of $CaSO_4$:Dy + Teflon (6 mm diameter, 0.8 mm thick) under plastic (polyethylene 3 mm thick), lead (1 mm thick) and special lead filter with central hole of 2 mm (0.8 mm thick) filters. Those 13 mm diameter filters are projected to minimize energy dependence. This work describes an effort to optimize the algorithm for dose and energy evaluation in the region of low energy based on the response of the $CaSO_4$ detectors under different filters. The energy dependence was calculated using PENELOPE Monte Carlo code and then compared to the experimental TLD results for X-rays effective energies with 33, 49, 65, 83 and 118 keV, and also for ^{60}Co gamma radiation. The results obtained from simulation and experimental measurements were normalized to ^{60}Co energy. Within method uncertainty, the simulated energy response shows a good agreement with experimental results.

1. INTRODUCTION

Thermoluminescence dosimeter using calcium sulfate doped with dysprosium ($CaSO_4$:Dy) produced at IPEN is used for dose evaluation in environmental and personal monitoring. Despite its energy dependence, $CaSO_4$ shows high sensitivity is that a distinct advantage [1]. The dosimetric system consists of a polyethyene badge with three discs of $CaSO_4$:Dy + Teflon (6 mm diameter, 0.8 mm thick) under plastic (polyethylene 3 mm thick), lead (1 mm thick) and special lead filter with central hole of 2 mm diameter (0.8 mm thick) filters. Those 13 mm diameter filters are projected to minimize energy dependence.

This work describes an effort to optimize the algorithm for dose and energy evaluation in the region of low energy based on the response of the $CaSO_4$ detectors under different filters using Monte Carlo simulation of deposited energy in the dosimeter.

2. MATERIALS AND METHODS

2.1 Dosimeter

Thermoluminescence dosimeter (TLD) using calcium sulfate doped with dysprosium ($CaSO_4$:Dy) produced at IPEN is used for dose evaluation [1]. The $CaSO_4$ dosimeter (0.1 mol% Dy) using Teflon as binding material.

2.2 Irradiation

The dosimeters were irradiated using the polyethylene badge. Irradiations in 33, 49, 118 and 1250 keV fields have been performed at Laboratório de Calibração de Instrumentos (IPEN). Irradiations in 65 and 83 keV fields have been performed at Laboratório Nacional de Metrologia das Radiações Ionizantes (IRD).

2.3 Monte Carlo Code

The PENELOPE (Penetration and Energy Loss of Positrons and Electrons) is Monte Carlo code which performs simulations of coupled electron-positron transport in material media for wide energy range [2].

The badge was divided in regions to simplify the simulations. The geometric configuration used in simulation is shown in figure 1.

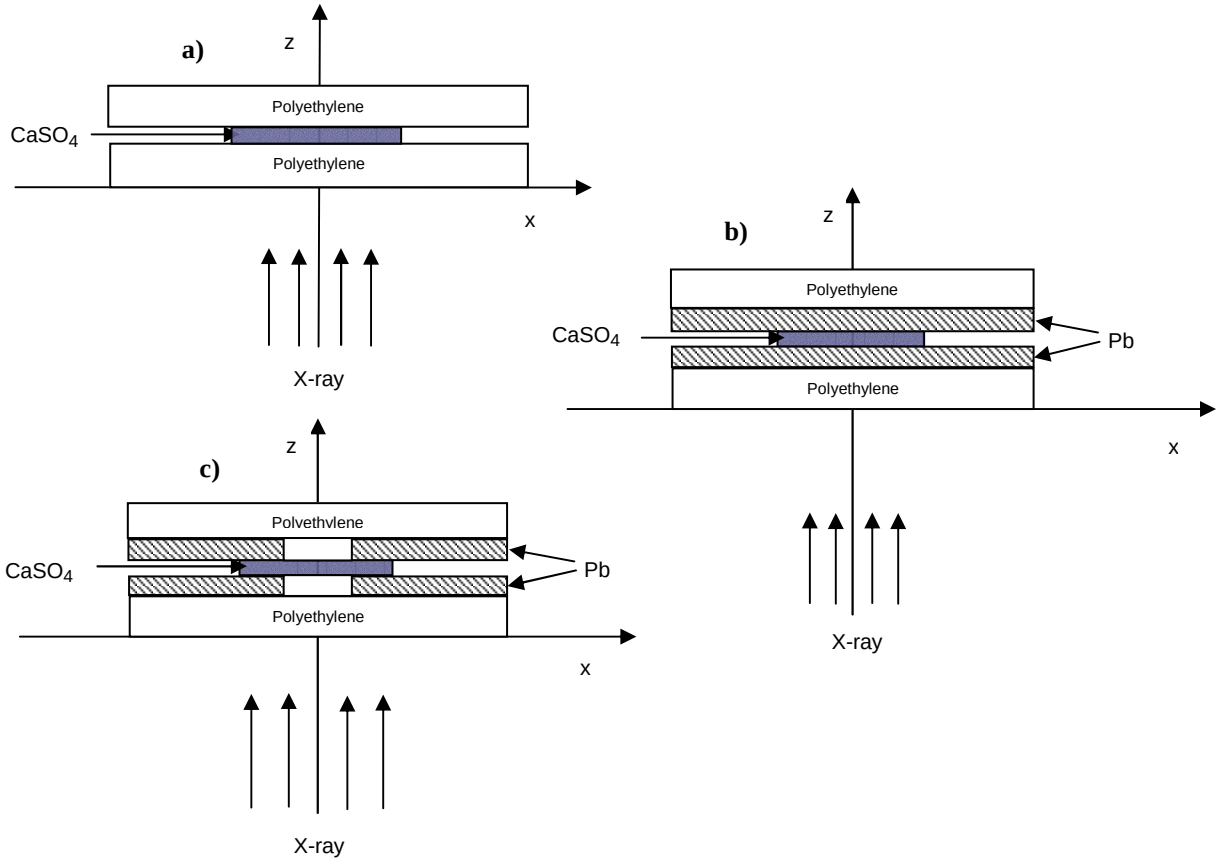

Figure 1. Geometric configuration used in the PENELOPE simulation: a) polyethylene filter; b) polyethylene+lead filter and c) polyethylene+lead filter with central hole.

In our simulation the parameters were fixed to the following values: cut-off kinetic energy E_{ABS}=1 keV for photon and electron transport; W_{CC} and W_{CR} in agreement with Sempau and Andreo [3] considerations; C1=C2=0.05; monoenergetic and parallel incident photon beam in energy range 10-1250 keV. At each energy, the histories of $1x10^8$ photons were simulated and produced relative uncertainties < 5%.

The tally absorbed dose was modified for generate absorbed dose in grays ($1MeV/g=1.6022x10^{-10}$ Gy). The mass energy absorption coefficients for air kerma normalization were obtained from NIST [4].

3. RESULTS

The energy dependence was calculated using PENELOPE Monte Carlo code and then compared to the experimental TLD results for X-rays effective energies with 33, 49, 65, 83 and 118 keV, and also for ^{60}Co gamma radiation. The results obtained from simulation and experimental measurements were normalized to ^{60}Co energy. The results show in figure 2.

The results of evaluation show good agreement with ± 25% relative error. For the simplify simulation some aspects have not been considered: influence of concentration and non-homogeneous distribution of Dy and influence of Teflon mixture. Chan et al. [5] demonstrates the Dy and Teflon concentration effects in absolute results are < 20%.

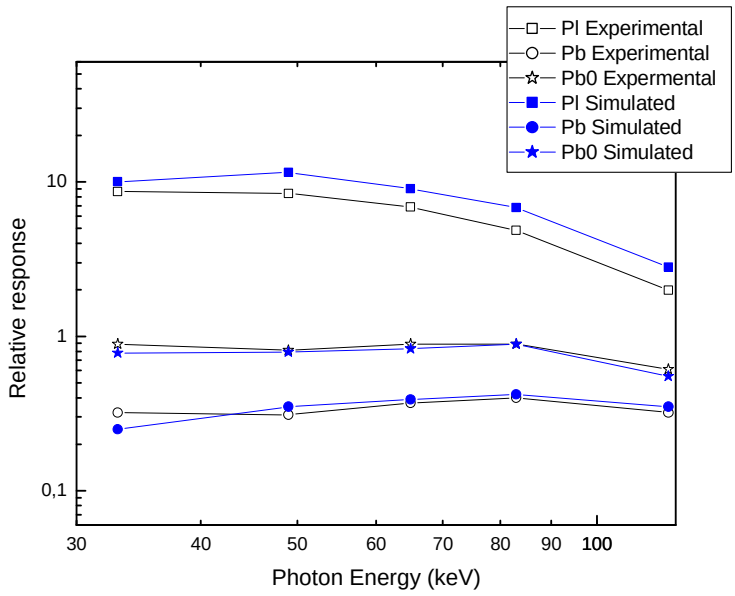

Figure 2. Measured and simulated relative absorbed dose.

4. CONCLUSIONS

The energy dependence of the TLD dosimeters at IPEN was simulated by using PENELOPE Monte Carlo code and compared with experimental data. The results of evaluation show good agreement with ± 25% relative error. For future studies it is necessary to include Dy and Teflon effects and more realistic geometry simulation.

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