Evaluating the relative TL efficiency of TLD-400 (CaF2:Mn) Thermoluminescence Dosimeter for heavy charge particle dosimetry

Jyun-Wei Jheng[1]
Tsi-Chian Chao[2], I-Chun Cho[3], Chien-Yu Lin[3] and Sen-Hao Lee[4]
[1] Department of Medical Imaging and Radiological Sciences, Chang Gung University
[2] Department of Medical Imaging and Radiological Sciences, College of Medicine, No.259, Wenhua 1st Rd., Guishan Dist., Taoyuan City, 333323, Taiwan
[3] Research Center for Radiation Medicine, Chang Gung University, No.259, Wenhua 1st Rd., Guishan Dist., Taoyuan City, 333323, Taiwan
[4] Department of Radiation Oncology, Linkou Chang Gung Memorial Hospital, No.15, Wenhua 1st Rd., Guishan Dist., Taoyuan City, 333011, Taiwan

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[1]Department of Medical Imaging and Radiological Sciences, Chang Gung University, No.259, Wenhua 1st Rd., Guishan Dist., Taoyuan City, 333323, Taiwan
[2]Research Center for Radiation Medicine, Chang Gung University, No.259, Wenhua 1st Rd., Guishan Dist., Taoyuan City, 333323, Taiwan
[3]Radiation Research Core Laboratory, Linkou Chang Gung Memorial Hospital, No.15, Wenhua 1st Rd., Guishan Dist., Taoyuan City, 333011, Taiwan
[4]Department of Radiation Oncology, Linkou Chang Gung Memorial Hospital, No.15, Wenhua 1st Rd., Guishan Dist., Taoyuan City, 333011, Taiwan

The Thermoluminescence Dosimeter (TLD-400) is composed of calcium fluoride doped with manganese (CaF_2:Mn), making it highly sensitive to ionizing radiation and capable of measuring a broad range of radiation doses. For instance, when exposed to a cobalt-60 photon beam, TLD-400 maintains a linear dose-response relationship over a range of 0.15 mGy to 100 Gy (Texeira, Cecatti, & Caldas, 2008). This dosimeter has potential applications in ultra-high dose rate particle radiotherapy, such as proton FLASH therapy.

A key characteristic of TLD-400 is its relative efficiency effect, meaning that under different types of ionizing radiation, even at the same absorbed dose, the thermoluminescence (TL) signal intensity varies. Consequently, external correction factors are necessary when applying TLD-400 for dose measurements across different radiation modalities. However, if systematic variations in relative efficiency ($\eta_{\lambda,\gamma}$) can be consistently observed under distinct beam conditions, this dosimeter may also serve as a tool for radiation type differentiation.

The purpose of this study is to evaluate the relative efficiency of TLD-400 under different radiation beam conditions and assess its feasibility for radiation type and beam quality differentiation. A 6 MV photon beam from a linear accelerator was used as a reference source, and the relative efficiency of TLD-400 was investigated under irradiation with 6 MeV and 9 MeV electron beams and 70, 110, 150, 190, and 230 MeV proton beams. The objective is to determine whether variations in relative efficiency can be systematically correlated with beam type and energy, thereby establishing TLD-400 as a potential dosimetric tool for beam characterization in radiation therapy and related applications.

The experimental results indicate that the relative efficiency ($\eta_{\lambda,\gamma}$) for electron beam irradiation at 6 MeV and 9 MeV was 0.87 ± 0.02 and 0.73 ± 0.01, respectively. For proton beam irradiation, the relative efficiencies were 0.67 ± 0.02, 0.70 ± 0.01, 0.69 ± 0.02, 0.75 ± 0.02, and 0.73 ± 0.03 for proton energies of 70, 110, 150, 190, and 230 MeV, respectively. As shown in the table.

	6 MeV (e)	9 MeV (e)	70 MeV (p)	110 MeV (p)	150 MeV (p)	190 MeV (p)	230 MeV (p)
$(\eta_{\lambda,\gamma})$	0.87 ± 0.02	0.73 ± 0.01	0.67 ± 0.02	0.70 ± 0.01	0.69 ± 0.02	0.75 ± 0.02	0.73 ± 0.03

This table shows the relative efficiency of TLD-400 under electron beam and proton beam irradiation. The "e" in brackets indicates electron beam, and the "p" indicates proton beam.

Reference

Texeira, M. I., Cecatti, S. G., & Caldas, L. V. (2008). Performance of thermoluminescent materials for high dose dosimetry.