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Evaluation of linearity response of a new nanocomposite dosimeter in a high dose per pulse intra-operative radiotherapy field

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Abstract

linearity response of a dosimeter is highly recommended during the in-field radiation dosimetry of a linear medical accelerator. The aim of this study is to evaluate the linearity response of a newly developed real-time polymer-Carbon Nanotube (CNT) nanocomposite dosimeter for 6 MeV electron beam of the LIAC machine, a high dose per pulse dedicated intraoperative electron radiotherapy (IOeRT). The dosimeter response was measured as the variation of electric current in the nanocomposite during the irradiation through the 6 MeV electrons with 10 cm reference applicator size using a PTW-UNIDOS E electrometer at the surface of a polymethyl methacrylate (PMMA) slab. The dosimeter response was increased by increasing Monitor Units (MUs) electron beam direction. Results showed that the dosimeter response was linear at various MUs ranging from 100-1500. The maximum standard deviation of readouts was measured as 1.2% in each MU. The suitable results of this study confirmed the application of polymer- CNT nanocomposite dosimeter in high energy radiotherapeutic field.

Keywords: CNT-nanocomposite dosimeter, LIAC dedicated IOeRT machine, linearity response.

Introduction

Radiotherapy is a routine treatment method of cancerous patients performed in different methods. Intra-operative electron radiotherapy (IORT) is a method that is a combination of surgery and radiotherapy at the same time. In this approach, a high single fraction of radiation dose (~20 Gy) is delivered to the anaesthetized patient after the tumor resection [1, 2]. According to Table 1. LIAC is a high dose per pulse dedicted IORT machine. In-field radiation dosimetry is very important for such devices. Different radiation dosimeters such as TLD[1], gafchromic EBT film and ion chamber were suggested for in-field radiation dosimetry of radiotherapy devices [2-4].

Usually, ion chambers due to temperature-pressure correction coefficients exhibited limitations. Also, Gafchromic EBT films and TLDs are passive dosimeters that need to be calibrated several times due to reading processing limitations [5-8].

Recently, polymer-nanocomposites exhibited suitable potential applications in radiation dosimetry, particularly in low-level radiations [9-15]. However, this research focused on applying a new polymer-nanocomposite dosimeter in high-level radiation beam energy of radiotherapy devices at 6 MeV.

Experimental

To measure the absorbed dose related to the 10 cm reference applicator at 6 MeV electron beam energy, a newly developed 10×20 cm^2 dimension with 2 mm thickness polymer/CNT nanocomposite dosimeter was applied. The dosimeter was connected to a PTW-UNIDOS E electrometer, and the operating voltage was fixed at 300 V. Measurements were performed on a surface of a polymethyl methacrylate (PMMA) slab with a monitor unit (MU) ranging from 100 to 1500. It should be mentioned that in all measurements, the distal end of the applicator was perpendicular to the PMMA slab surface. As shown in Figure 1, the set-up was depicted accordingly.

Table 1. Technical data of LIAC accerlerator [2,3].

Spacification	Value
Energies	6, 8, 10 and 12
Surface Dose	> 85 %
Leakage current	1.5 mA
Field Size	3,4 5, 6, 7, 8,9 and 10 cm
Flatness	6 ،7 ،8، 10 cm Φ ٪3 ≥ 5 cm ,4 Φ ٪5 ≥ 3 cm Φ ٪9 ≥
Symmetry	٪3 ≥
Applicator length	60 cm
Source to Surface Distance (SSD)	71.3 cm
Dose Rate	20 Gy/min
Pulse Frequency	60 Hz
Electron pulse duration	4 µs

[1] Thermoluminescent Dosimeter

Long term Stability	< 3%
Linearity	<1%
PDD bremsstrahlung tail	0.7% >

Results and discussion

The linearity response of polymer/CNT nanocomposite dosimeter is exhibited in Figure 2 at various monitor units (MU) for 6 MeV electron energy. This figure shows that the dosimeter response of this material is linear at various MUs, which can be used as a novel dosimeter for clinical applications. The maximum standard deviation of readouts was measured as 1.2% in each MU.

Figure 1. Experimental setup to measure dosimetry response of polymer/CNT nanocomposite using the LIAC dedicated IOeRT machine.

The other dosimetry characteristics, including energy dependence, angular dependence, field size, repeatability, reproducibility, long-term stability of dosimeter response, are in progress.

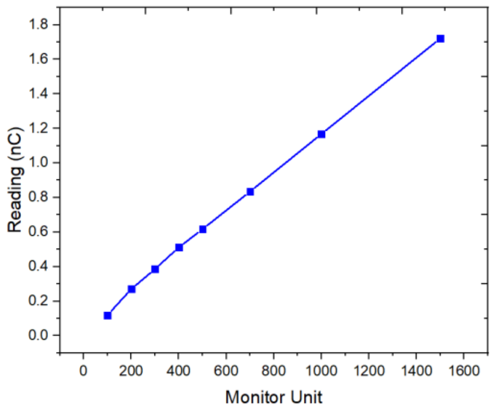

Figure 2. Evaluation of linearity response of polymer/CNT nanocomposite dosimeter in various MUs

at 6 MeV electron beam and 10cm reference applicator at 300 V operating voltage.

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Conclusions

In conclusion, in this experimental research, for the first time, the linearity response of a polymer/CNT nanocomposite dosimeter was measured in a therapeutic field using the LIAC IOeRT machine. Results showed that this material could be an excellent candidate as a dosimeter in radiotherapy centers.

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