Plastic scintillating fiber dosimetry for small animal irradiation

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Introduction:

Small animal image-guided irradiation systems for preclinical research deliver millimetric beams of medium energy X-rays (<250 keV), scaled to small animal size. Plastic scintillating fiber detectors are interesting for the dosimetry of such beams since they combine small detection volume, direct reading and a composition close to the water's one. However, they can suffer from energy dependence called "quenching" in the low energy region. In this work, we have conducted a characterization of our plastic scintillator dosimeter prototype and the energy dependence study of its sensitivity. First measurements in millimetric beams will also be presented.

Materials and methods:

Our dosimeter prototype, called Dosirat, is composed of a 1mm diameter and 15mm long polystyrene based plastic scintillating fiber coupled to a clear optical fiber. The light output signal induced by irradiation is measured by a photodiode coupled to an electrometer. All irradiations have been performed with the image-guided X-Rad 225Cx irradiator (PXI Inc.) installed in Caen. Repeatability and linearity measurements have been performed. Dosirat response to energy has then been evaluated for different beam qualities and compared to measurements with an ionization chamber and to Monte Carlo simulations. Relative output factors (ROF) have been evaluated with a 4mm long scintillating fiber for 10x10cm² to 1mm diameter field sizes and compared to the corresponding ROFs of EBT3 dosimetric films.

Results:

Our dosimeter has shown excellent repeatability (<0.15%) and a linear response with dose and dose rate, for dose rates from 10 to 293 cGy/min. The energy dependence study has shown that Dosirat sensitivity (pC/Gy) expresses a 7% variation over the tested energy range (80 to 225 kV, 2mm Al or 0.3 mm Cu additional filtration). It has been identified as scintillation quenching. The ROF curve, normalized to the 10x10cm² field size, is consistent at 4% with the ROF curve obtained by the EBT3 dosimetric films, up to 5mm diameter field size.

Conclusion:

These results show interesting performances of Dosirat at medium energy. Accurate dosimetry can be achieved by calibrating the dosimeter for any required beam quality. Hence, Dosirat is a promising dosimeter for small animal irradiation, particularly for *in vivo* dosimetry which concerns our next study. Scintillating fiber dosimeters could also be used in the clinical areas using medium X-ray energies such as diagnostic radiology, brachytherapy or intraoperative radiotherapy.