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(G*) Real-time behavior of radiochromic materials in standard proton and photon, and electron FLASH beams

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Purpose: With advancements in high dose rate radiotherapy techniques such as FLASH therapy, radiochromic films have been proposed as a key dosimeters due to their relative dose rate independence when used with standard read-out methods. Our group is interested in understanding the real-time behaviour of these materials in order to develop radiochromic optical probes for real-time dosimetry, with utility across a broad range of beam qualities and applications.
Methods: Three radiochromic formulations were made with 10,12-pentacosa diynoic acid (PCDA) and its lithium salt (LiPCDA), with varying Li+ ratios (PCDA, 635LiPCDA, and 674LiPCDA). The formulations, coated onto polyethylene, were irradiated within a custom real-time jig equipped with optical fibres for continuous data collection before, during and after irradiation. The light source is a tungsten halogen lamp, and the light transmitted through the film was collected by a CCD camera. The three radiochromic formulations, and commercial EBT-3 for benchmarking, were irradiated to 0-25 Gy with a 74 MeV proton beam (TRIUMF), a 6MV photon beam (clinical linear accelerator (LINAC), University Health Network), and an electron FLASH beam (decommissioned LINAC). The transmitted light was processed to calculate optical density around the main absorbance peak for each formulation.
Results: All in-house films and commercial EBT-3 showed an instant sharp increase in optical density with absorbed dose, including under FLASH conditions. For all three beam modalities, 635LiPCDA (comparable to current commercial products) exhibited the highest sensitivity, followed by 674LiPCDA, and PCDA (comparable to older products) respectively. As previously observed for commercial radiochromic films, all formulations demonstrated a lower response per dose when irradiated with protons due to quenching effects.
Conclusions: We demonstrate that LiPCDA crystals can be selectively grown to exhibit tailored dose responses. For the first time, we show that real-time response in standard proton beams and under electron FLASH conditions are characterized by an immediate sharp increase in optical density with absorbed dose, followed by an expected asymptotic shoulder due to post-exposure polymerization.

Keyword-1

Radiochromic

Keyword-2

Real-time

Keyword-3

Proton

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