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(G*) Optical stability investigation of a calibrant IR dye for radiochromic dosimetry

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Our group is developing a plastic fiber optic probe dosimeter based on a radiochromic sensor for real-time in vivo dosimetry. The active component of the probe material is a lithium pentacosanoate (LiPCDA) coating on the order of microns in thickness. In radiochromic optical dosimeters both sensitivity and active material thickness variations in manufacturing can lead to uncertainty in the dose measurement. Thus, to confidently determine the dose, independent of optical path length variations in the interrogation beam arising from different radiochromic film thicknesses, an inert homogeneously incorporated infra-red (IR) dye such as IR-783 and IR-806 can be added to the LiPCDA formulation for calibration. This enables an accurate thickness correction using the Beer-Lambert law. For use as a calibrant, however, these dyes must be both stable in ambient environmental conditions over time and resistant to radiolysis. To investigate the stability of these IR dyes, LiPCDA gelatin-based coatings from the two proposed IR dyes were prepared. The coatings were left in ambient conditions in a dark space, and their absorbance spectra were measured frequently for >100 days. We performed control experiments with IR-783 and IR-806 dyes to investigate degradation in time without the active LiPCDA material, which showed average decay lifetimes of $\tau = 73 \pm 7$ days and $\tau = 7 \pm 3$ days, respectively for IR-783 and IR-806. When incorporated with LiPCDA, IR-806 showed a significant shift in the main absorbance peak, overlapping with the dosimeter active component. Comparatively, IR-783 combined with LiPCDA did not show significant overlapping peaks in the spectrum and exhibited single exponential decay behaviour with a faster decay rate ($\tau = 4 \pm 1$ days) relative to the control. IR-783 was further observed to be insensitive to ionizing radiation dose. Therefore, IR-783 may be a suitable dye for calibrating radiochromic dosimeters given its predictable and reproducible exponential decay behaviour.

Keyword-1

Radiochromic dosimetry

Keyword-2

Optical calibration

Keyword-3

Lifetime stability

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