

Optical Calibration of Radiochromic Film Thickness With IR Dye

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INTRODUCTION

- radiochromic films using Lithium pentacosanoate (LiPCDA) as the radiosensitive component have been shown to be suitable for use as a real time dosimeter¹ in an optical fiber probe configuration²⁻⁴
- sensitivity defined as change in optical density (OD) per dose absorbed by the material
- sensitivity of radiochromic films is a function of thickness of material^{3,5}
- variations in sensitivity of commercial dosimeters typically calibrated for by medical physicist
- calibration requires irradiation of dosimeters to known dose
- calibration may be performed by optically measuring thickness using Beer Lambert Law

$$A = \epsilon cl$$

where ϵ is the extinction coefficient in $\text{mol}^{-1} \text{cm}^{-1}$ (or L/g cm^{-1}), c is the concentration of absorber in mol (or g/L), and l is the measured path length

- path length is the radiochromic coating thickness, proportional to sensitivity

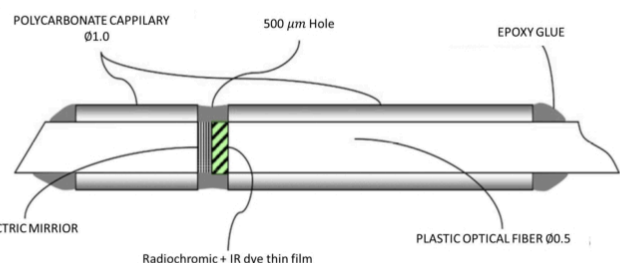


Figure 1. Schematic of optical dosimeter probe.

- the absorber used must be:
 - optically distinct from the peaks of LiPCDA in near-infrared (near-IR)
 - stable with radiation dose
 - stable with time
 - homogeneously distributed within coating

AIM

- to optically calibrate for variations in LiPCDA radiochromic film thickness, for use in a real-time fiber optic dosimetry, through the incorporation of an IR dye

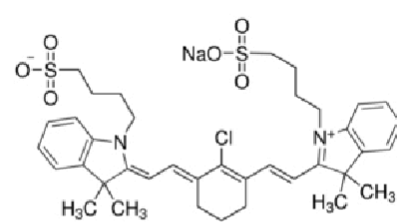
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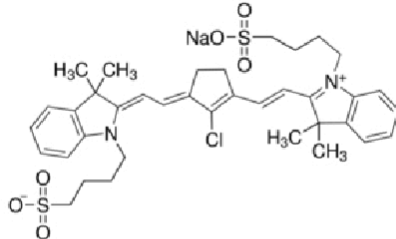
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METHOD

- four cyanine IR dyes with absorbance peaks at 783 nm, 806 nm, 868 nm and 880 nm



IR-783



IR-806

- IR dyes dissolved in deionized water (Millipore Milli-Q) (2 stock batches/dye) and diluted to different concentrations
- absorbance spectra measured on UV-VIS (1 cm cuvette, Varian Cary 50) on Day 0 and subsequent days (up to 5 aliquots)
- one dye (IR-783) incorporated into the coatings on Mylar™ substrate
- coatings irradiated with 254 nm UV light to initiate polymerization
- change in absorbance measured with UV-VIS

RESULTS

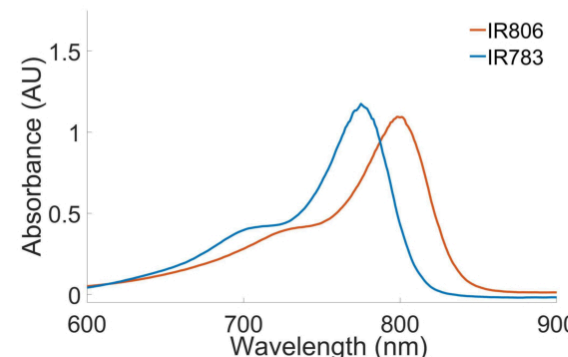


Figure 2. Absorbance spectra of IR-783 and IR-806 in deionized water (at 0.0044 g/L and 0.0075 g/L, respectively). A shift in absorbance peak is observed due to use of water, instead of methanol (to 775 nm and 801 nm, respectively). Less than 0.005% of total mass resulted in absorbance >0.5 at the main peak in solution.

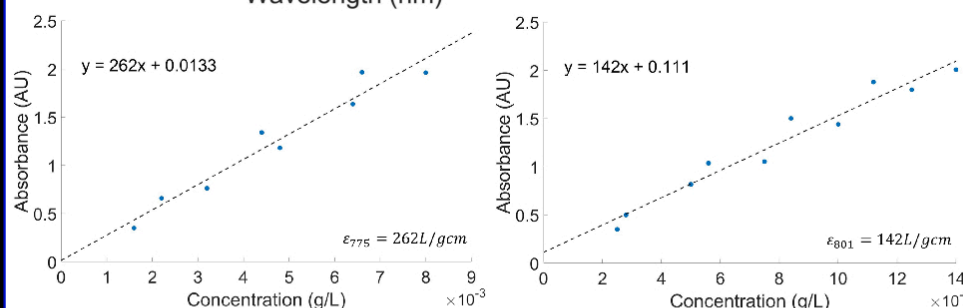


Figure 3. Calibration curves for IR-783 and IR-806 in deionized water, showing a linear increase in absorbance over the selected concentration range.

- to produce a peak of 0.6 OD in optical probe, 0.62g/L and 1.2 g/L required for IR-783 and IR-806 dyes, respectively (20 µm coating)
- IR-806 at >0.0102 g/L has shown to be unstable in aqueous solution⁶

RESULTS

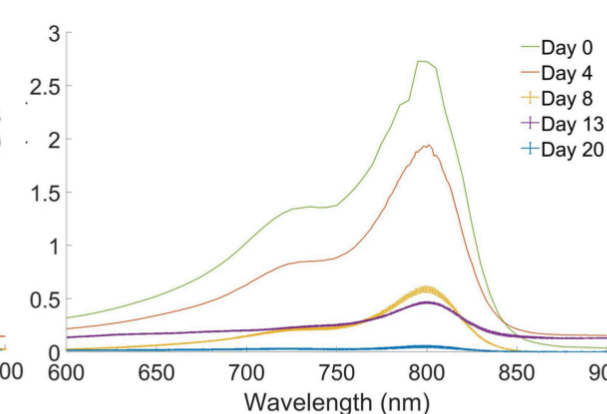
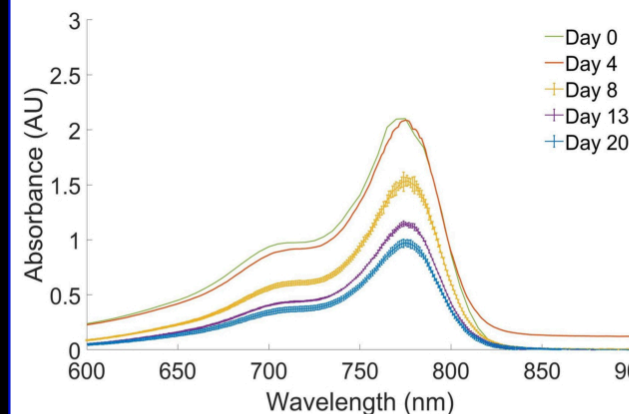


Figure 4. Absorbance spectra of IR-783 and IR-806 in deionized water (at 0.008 g/L and 0.014 g/L, respectively) as a function of time. Errors bars represent single standard deviation of five aliquots.

- absorbance peak maximum of IR-783 was stable in solution for 0-4 days
- IR-806 showed a peak absorbance drop within the first 4 days in solution
- main absorbance peak of IR-783 shifted to 800 nm once incorporated into LiPCDA coating
- absorbance of IR-783 was stable with absorbed dose from 254 nm UV light
- IR-783 peak did not interfere with the 635 nm absorbance peak of the LiPCDA

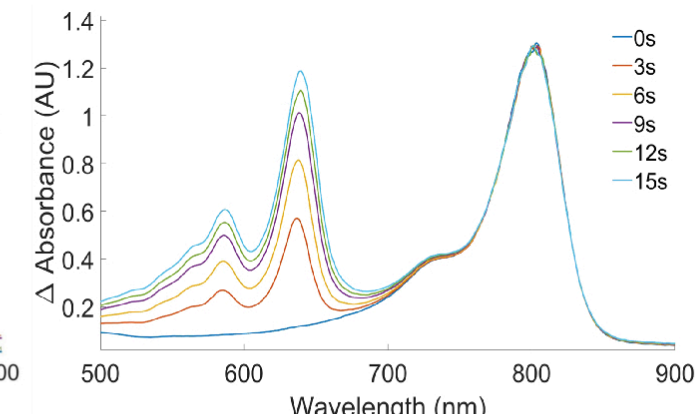


Figure 5. Change in absorbance of LiPCDA coatings on Mylar™ substrate with IR-783 integrated as a function of time irradiated with 254 nm UV light.

Figure 6. Photograph of LiPCDA coatings on Mylar™ substrate with IR-783 integrated before and after (left and right, respectively) irradiation with 254 nm UV light.



CONCLUSIONS

- IR-783 and IR-806 are water soluble; IR-808 and IR-880 are not
- extinction coefficient reduces with prolonged time in solution, with IR-806 no longer having a detectable absorbance peak after 2 weeks
- IR-783 is stable in solution over the first several days
- ϵ for IR 783 in aqueous solution sufficient for use in thin coatings
- IR 783 spectrum and ϵ is stable under UV irradiation
- IR 783 may be a suitable dye for optical calibration in a radiochromic LiPCDA coating
- stability in coatings as a function of time and environmental conditions needs to be verified
- stability in coatings as a function of kV and MV beam dose needs to be verified

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