

Results from In Situ Monitoring of Radiation Damage of Scintillation Fibers

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Abstract—We report preliminary results from in situ monitoring of an optical scintillating fiber while being exposed to a cesium-137 gamma radiator. We measured the degradation of fiber transmittance across the visible spectrum as a function of time. We observed that the region below 500 nm was degraded quickly and thoroughly while wavelengths above 500 nm lost clarity more slowly.

I. INTRODUCTION

RADIATION exposure creates color centers in plastic scintillators which increase their opacity [1] as a function of dose. Scintillators generate photons in proportion to the energy of a transiting particle [2], therefore characterizing the opacity of a scintillator as a function of absorbed radiation dose is of importance to experiments. While experiments have been conducted on scintillator integrated opacity as a function of dose, there is a dearth of experimental study of scintillators measured while being exposed to radiation. We were interested in observing the real-time decay of a scintillator as a function of wavelength. We report the results of such an experiment in this article.

II. EXPERIMENTAL SETUP

Utilizing the elongated cesium-137 radiator at the University of Iowa Free Radical and Radiation Biology Research Core, we installed an optical scintillating fiber to receive 22 Gy per minute of gamma radiation. The fiber was connected via quartz fiber between an Ocean Optics PX-2 xenon lamp with a broad spectrum emission between 400 and 800 nm. The PX-2 was pulsed 50 times and those 50 measurements averaged using the Ocean Optics Spectrasuite software every 10 minutes. Prior to each measurement, a separate dark pulse measurement was taken with the lamp off and stored into memory, where it was subtracted from the averaged measurement before it was saved. The spectrometer and quartz fibers were shielded with

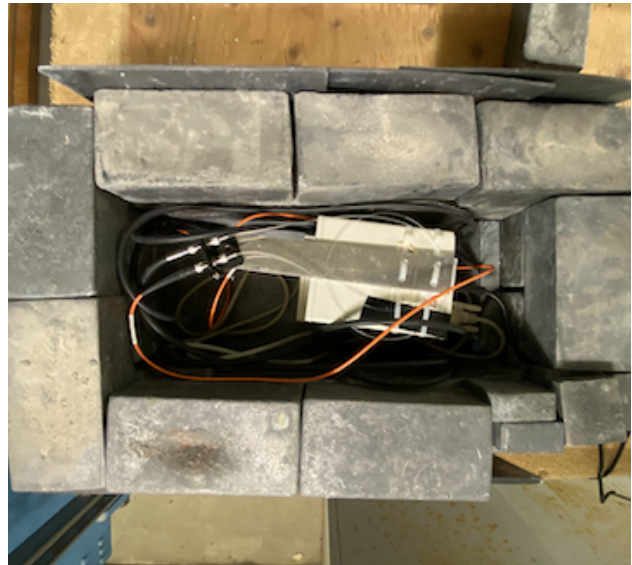


Fig. 1. Spectrometer, control fiber, and quartz fiber in lead sarcophagus.

blocks of lead and formable sheets of lead to ensure only the scintillating fiber was exposed to radiation.

The fiber irradiated was manufactured by Kuraray and is the B-2 (200) UV to blue wavelength shifting fiber.

A control measurement was made using a second identical fiber connected in parallel, kept within the lead shielding and measured concurrently. This measurement was used to verify the stability of the PX-2 light source.

The attenuation of the fiber is calculated by dividing the spectrum at a given time into the spectrum taken at the start of the irradiation.

Figs. 1 and 2 show the setup in the radcore facility.

III. RESULTS

Rather than display every taken measurement, Fig. 3 shows a subset of waveforms selected at regular intervals. The B2(200) fiber from Kuraray is reported to have a peak luminescence at 437 nm by the manufacturer. This regime is fully attenuated in the fiber after approximately 20 kGy of gamma radiation exposure, or 15 hours irradiation at a dose rate of 22 Gy/min. The region above 700 nm was more resistant to radiation exposure, losing only 40 percent after 22 kGy of exposure.

We were concerned that the intensity of the PX-2 light source might not be stable over a 24 hour period. The manufacturer states that continual running can heat the bulb and change the intensity of the emission. We mitigated this by pulsing once

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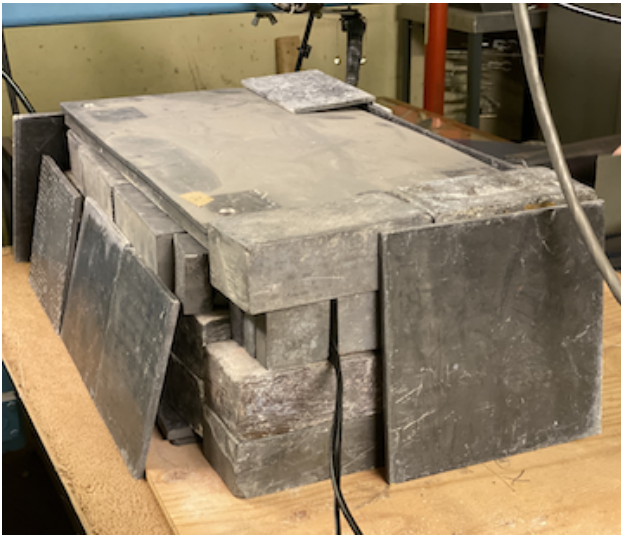


Fig. 2. Spectrometer, control fiber, and quartz fiber in lead sarcophagus with lid.

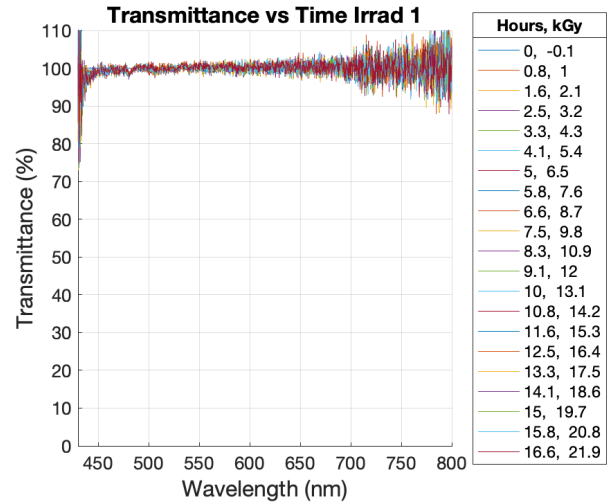


Fig. 4. Identical Kuraray B2(200) scintillating fiber used as a control.

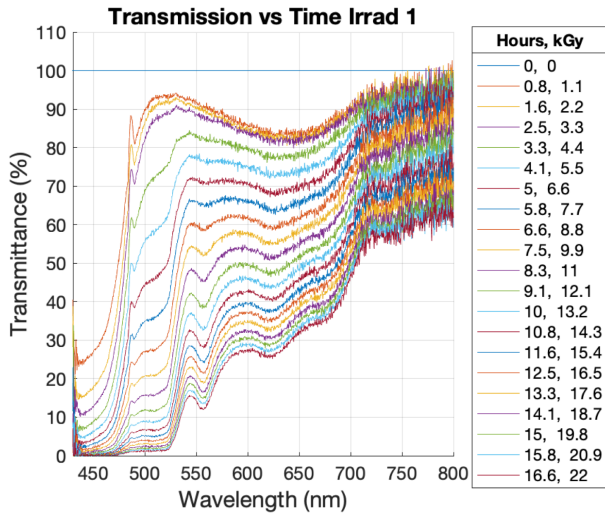


Fig. 3. Selected visible spectrum transmittance measurements over 22 hours of irradiation for a Kuraray B2(200) scintillating fiber.

every 10 minutes, and taking a control measurement. Fig. 4 shows that the PX-2 light source was stable over the entire experimental run.

IV. DISCUSSION

The most striking feature of this data is the rapid attenuation within the UV-blue region. We observed a 70 percent reduction in light transmission below 500nm after only 1.1 kGy exposure. For context, scintillators in modern collider experiments need to withstand exposure to at least 10 kGy. For a fiber that scintillates in the blue region, this is a fatal dose, and it occurs quickly. Scintillators also exhibit a recovery behavior, regaining lost transmittance after exposure to radiation stops. It would be interesting to run this experiment multiple times on the same fiber, allowing it to recover between each irradiation. The relatively slow drop in attenuation of wavelengths above 700

nm might make orange or red scintillating fibers an attractive technology for future development. We plan to repeat these measurements with other fibers, as well as conduct repeat irradiations.

V. CONCLUSION

Kuraray B2(200) UV-blue wavelength shifting fibers were exposed to a cesium-137 radiator for 24 hours. Every 10 minutes we observed the spectrum of light using an Ocean Optics spectrometer and PX-2 xenon lamp. A control fiber was measured simultaneously. We calculated and reported the transmittance of these fibers as a function of time, observing a quick attenuation of wavelengths below 500 nm compared to wavelengths above 500 nm.

ACKNOWLEDGMENT

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