INVESTIGATION OF PLASTIC MATERIAL PROPERTIES EXPOSED TO ULTRA-HIGH DOSE RATE ELECTRON BEAM

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UHDpulse

Purpose: The equipment used in dosimetry for FLASH-RT (detectors, water tanks, etc.) are exposed to radiation with a dose per pulse (DPP) about 10^3 times larger than CONV-RT, which significantly reduces their lifetime. This work aims to investigate the most suitable plastic materials for use in the FLASH modality.

Methods: PMMA and PEEK® samples have been exposed up to 10^6 Gy at a DPP of 11 Gy using a 20 MeV electron beam at 10 Hz pulse repetition frequency.

- Optical density change of irradiated PMMA samples was evaluated using a densitometer for all dose levels listed in Table 1 and was monitored over 4 weeks after irradiation to quantify the optical recovery effect.
- Mechanical properties of the irradiated samples were evaluated with a durometer for hardness tests (Shore D scale).

Results: No significant change in the PEEK properties have been observed; only a qualitative change in colour has been detected. The light transmission of the PMMA reduces with the increasing dose exposition (35(2)% decrease at 10^6 Gy). As expected, an optical recovery effect was observed as shown in figure 1. A slight change of hardness measurement at the dose level of 10^5 Gy was observed, 0.8(2)%. The first cracks formation in PMMA has been observed at the dose around 750 kGy.

Table 1: The dose levels for qualitative change in the mechanical properties and significant qualitative discolouration.

	Dose levels (Gy)						
Material	0	10^2	10^3	10^4	10^5	$5x10^5$	10^6
PMMA							
PEEK®							

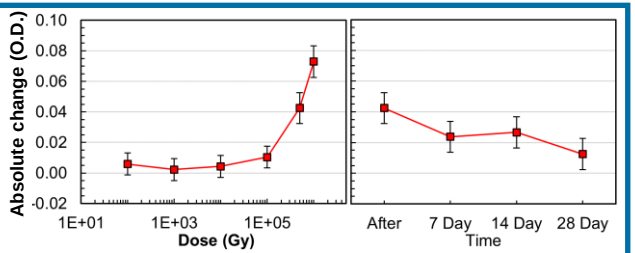

Figure 1: Absolute change in optical density of PMMA samples after irradiation and over time for 0.5 MGy dose level.

Conclusions: This investigation has shown that PEEK® would be a suitable material for FLASH-RT since no significant change in the material properties was observed in the dose level investigated. PEEK® is also used for detector mounting and it has been evaluated that the piece has sustained over 25 MGy without visible radiation damage. However, PEEK® is an opaque material, therefore, not suitable for water tanks. The results with PMMA indicated that FLASH-RT equipment should no longer be built with such material.

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