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# EVALUATING THE RHEOLOGICAL BEHAVIOR OF IRRADIATED 3D-PRINTED PLA PARTS FOR MEDICAL APPLICATIONS

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ABSTRACT

Polylactic acid (PLA) is a widely used biopolymer in medical applications due to its biocompatibility, biodegradability, and ease of processing, especially by 3D printing. In radiotherapy, 3D-printed PLA parts are utilized to ensure precise dose delivery. However, the exposure of PLA to high-energy irradiation during treatment might accelerate its degradation, posing challenges for reuse and recycling. Therefore, this study investigates the effects of repeated recycling on the rheological behavior and, therefore, on the processability of 3D-printed PLA parts subjected to irradiation. PLA parts were irradiated with doses commonly delivered in radiation oncology, corresponding to 10 treatments at 60 Gray each, and subsequently recycled through thermo-mechanical processes. These involved filament extrusion, 3D printing, and regrinding to experimentally simulate a closed-loop recycling process. The microstructural and rheological properties are evaluated across multiple recycling cycles using techniques such as differential scanning calorimetry, Fourier transform infrared spectroscopy, and rotational rheometry. The polymer degradation is further correlated with its rheological performance during extrusion and 3D printing, focusing on flow behavior, and dimensional stability of the printed parts. Preliminary results indicate that irradiation can significantly reduce the molecular weight of PLA, leading to faster thermal degradation in subsequent cycles. Despite these changes, the material retained acceptable rheological properties for recycling up to four times without the addition of any neat material. Ultimately, this research provides critical insights into the recyclability of irradiated PLA in hospital environments, aiming to enhance the sustainability of 3D-printed medical parts. Thus, understanding the interplay between irradiation-accelerated degradation and the material's rheological characteristics is essential for optimizing recycling strategies and minimizing environmental impact.