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4D PRINTING OF PNIPAM-BASED HYDROGELS: EFFECTS OF CROSSLINKING RATES AND THICKNESS VARIATIONS

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ABSTRACT

Hydrogels have garnered significant attention in fields such as tissue engineering due to their exceptional properties, including biocompatibility with various cell types and customizable characteristics. In this study, we focused on Poly N-Isopropylacrylamide (PNIPAM)-based hydrogels, which exhibit a lower critical solution temperature close to human physiological temperature. Despite their potential, further investigation is needed to understand how manufacturing processes influence the mechanical performance of printed structures. Among additive manufacturing techniques, in-vat polymerization processes are particularly effective for fabricating NIPAM-based hydrogels. Digital light processing (DLP) stands out due to its high resolution, rapid printing speed, precise dimensional and spatial control, isotropy of printed layers, and cost efficiency compared to other vat polymerization methods.

This study explores the influence of crosslinking rates and thickness on the folding behavior of 4D-printed NIPAM-based hydrogels produced via the DLP process. Two distinct printing methodologies were examined: (i) samples with constant thickness exposed to uniform light intensity across their surfaces, and (ii) samples with constant thickness subjected to a gradient light intensity across the surface. Results reveal that sample thickness significantly impacts bending behavior. Additionally, variations in light intensity lead to differences in crosslinking rates, where regions with higher crosslinking rates exhibit greater rigidity and reduced bending capabilities.