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PROCEEDINGS

Rapid Volumetric Printing of Multi-Material pH-Responsive Drug Delivery Systems

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ABSTRACT

With the advancement of the personalised medicine industry, multi-material targeted drug delivery systems have garnered significant attention due to the higher drug bioavailability and synergistic effects of combined drug therapies. However, the fabrication throughput of such systems often fails to satisfy the demands of clinical applications. Volumetric printing, distinguished by its remarkable capability for rapid fabrication, presents a promising approach for fabricating these systems. Nevertheless, during volumetric printing, formed parts are prone to displacement relative to their intended locations due to variations in ink density, viscosity, and other factors, resulting in geometric distortion and complicating multi-ink switching. Moreover, functional inks like pH-responsive materials often exhibit high absorbance, resulting in low light penetration and causing printing failures. Consequently, the volumetric printing of multi-material targeted drug delivery systems remains challenging. To address these challenges, this research pre-embedded auxiliary support mechanisms within the forming chamber for precise positioning and fixation of formed components while enabling efficient multi-ink switching. Concurrently, the mathematical mapping relationship between the material absorbance and printing parameters (such as the dimensions of the forming chamber and print parts) was derived based on Lambert-Beer law to guide the optimisation of the process. Leveraging the methodology above, a pH-responsive ink formulation (composed of poly (ethylene glycol) diacrylate, sodium alginate, carboxymethyl chitosan, and lithium phenyl-2,4,6-trimethylbenzoylphosphinate) suitable for volumetric printing and associated processing parameters (25 mW/cm^2 irradiation intensity, 2% calcium chloride secondary crosslinking for 15 min) were optimised by spectroscopic characterisation of the ink and analysis of swelling behaviour and drug release profiles of printed tablets. Those parameters enabled the rapid fabrication of multi-material, pH-responsive tablets capable of targeted multi-drug release. In conclusion, this study provides an effective approach to addressing critical technical obstacles in multi-material volumetric printing and demonstrates its considerable promise for the advancement of personalized biomedical device fabrication.

KEYWORDS

Volumetric printing; rapid fabrication; multi-material; pH-responsive drug delivery

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