

ENCAPSULATION OF BACTERIAL CELLS USING NOVEL FUSED DEPOSITION MODELING BASED 3D-PRINTED POLYLACTIC ACID MICROFLUIDIC DROPLET GENERATOR

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This study presents the development and application of a novel fused deposition modeling (FDM) based 3D-printed microfluidic droplet generator with a flow-focusing geometry fabricated using poly(lactic acid) (PLA). The vertical channel design was printed using an “Ultimaker-2” with a resolution of 60 μm . The optimal flow rates were determined to be 20 mL h^{-1} for the continuous phase (paraffin oil) and 2 mL h^{-1} for the dispersed phase (water), based on preliminary droplet generation tests. Under these optimized conditions, the device was employed for the encapsulation of *Bacillus subtilis* bacterial cells, obtained under aseptic conditions. The bacterial concentration was first determined using the Breed counting method. Microscopic observations and calculations using the Breed method equation revealed a bacterial density of approximately 2.3×10^9 cells mL^{-1} . A 2.0 mL solution of this bacterial suspension was prepared, with the addition of crystal violet for enhanced visualisation. This solution served as the dispersed phase during encapsulation. Droplet formation and encapsulation were successfully conducted using the optimised microfluidic device. The process yielded stable droplets containing approximately 100 bacterial cells per droplet, with an average droplet diameter of ~ 160 μm . Microscopic images confirmed the integrity and uniformity of the encapsulated droplets. To preserve their structure for observation, the droplets were aseptically transferred onto a cavity slide, minimising deformation during analysis. These findings validate the capability of the PLA-based 3D-printed device to serve as a cost-effective and reliable platform for bacterial encapsulation. The success of this application highlights its potential utility in microbiology, biotechnology, and point-of-care diagnostics, especially in resource-limited settings where traditional cleanroom fabrication methods are inaccessible.

Keywords: Cell encapsulation, FDM 3D printing, Flow focusing, Microfluidic devices, PLA