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Developing a Biocompatible Formulation for Stereolithographic 3D Printing

To determine how factors such as biofilm structure and microbial density affect the production of specific metabolites, and to address the mass transport and material property limitations inherent in naturally-formed biofilms, we propose to use stereolithography (SLA)-based 3D printing to construct biofilms with well-defined structures and properties. In this approach, a solid object is built up layer-by-layer from a liquid resin using a focused laser spot. Polymerization occurs at the laser focal point, which is raster scanned within the resin bath. Recently we have developed a biocompatible, water-based formulation for printing viscoelastic hydrogels using a commercial SLA 3D printer (Formlabs, Form 2). The formulation relies on free-radical polymerization of a polyethylene glycol-diacrylate (PEG-DA) monomer dissolved in water, which is initiated by a photoinitiator (LAP) responsive to 405 nm wavelength light. Microbes, such as A. sarcoides, Escherichia coli, Bacillus subtilis, and Pseudomonas aeruginosa, which are suspended in the liquid are entrapped in the PEG-DA hydrogel as it polymerizes and survive for extended periods of time. Moreover, PEG-DA provides a versatile platform for varying gel mechanics because parameters such as elastic modulus and toughness can be tuned by controlling the concentrations and ratios of divalent and trivalent PEG-DA monomers. This flexibility is important as the microbe-loaded hydrogels are not naturally-formed biofilms, and effort must be taken to determine how closely microbes embedded in our hydrogel replicate biofilm behavior. To do this, we must understand how parameters such as gel mechanics and chemical modification of the gel polymers impact gene expression.

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