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Design and Fabrication of Microfluidic Flow Focusing Devices for Drug Delivery Vehicle Development

While the lifespan of humans has increased, the durability of cartilage has not, leading to increasing rates of arthritis in aging humans. UVM's Engineered Biomaterials Research Laboratory (EBRL) is working to solve this problem using engineered tissue scaffolds with controlled mechanical properties, and encapsulated therapeutic drugs and human mesenchymal stem cells (hMSCs). In order for the drugs inside a scaffold to be released at the optimal rate, they are contained within polymeric microspheres having specified diameter, surface energy, and chemical structure.

In order to produce these microspheres, we turn to the field of microfluidics, which examines fluid interactions at micro-scale geometries and flow rates. A microfluidic flow-focusing device (MFFD) leverages the low Reynolds numbers and pronounced effects of surface tension in such flows to produce homogeneous droplets of one fluid in another.

While many methods for fabricating MFFDs exist, only some are suitable for this application. The most consistent method we have found involves fabricating a resinous mold, creating patterned channels in PDMS using soft photolithography, and bonding the device to a glass slide.

Thus, this project investigates the design and fabrication of MFFDs for the production of homogeneous microspheres containing drugs within a alginate-graft-poly(ethylene glycol) hydrogel. The MFFD must be consistently reproducible and easy to use, while exhibiting the correct channel dimensions to within 5μm in order to produce the correct microsphere diameter. The MFFD shows great potential to successfully play its role in the EBRL's investigation of engineered tissue scaffolds.