Tissue engineering is a multidisciplinary effort that aims to develop methods for the artificial synthesis of materials that mimic biological tissues. These methods require developing a substrate that promotes cell growth in the desired form factor. 3D printing technology has enabled researchers to create custom objects in a wide array of shapes and functionalities. However, the most commonly available 3D printers operate at elevated temperatures (typically above 100ºC) in order to melt a polymer filament into a moldable state, precluding their use with live cells. In this work, we have studied an alternative method – namely, the printing of a viscous reactive solution that is polymerized (gelled) as it emerges from the print head. As the photopolymerization of gels containing live cells is well-studied and commonplace, this approach opens the possibility of printing live cells in a 3D structure.

A custom 3D printer based on the RepRap family of open design machines was constructed to allow for the handling of liquid pre-polymer solutions. A photoactive pre-polymer solution, utilizing methacrylated hydrophilic polymer chains formed using a microwave synthesis, is fed to the print head of this printer where it is exposed to UV light. Upon exposure, this pre-polymer solution polymerizes and yields a crosslinked, hydrophilic polymer network, also known as a hydrogel. Our method differs from existing 3D photopolymerization printing in that reactant is used only where printed, yielding little to no waste, a crucial requirement in the printing of expensive biological components.

Pre-polymer solution is loaded into a syringe which is then inserted into a software-controlled syringe pump. The pump initiates flow through a short segment of Teflon tubing, emerging in a machined print head. The fiber-coupled LED (Thor Labs, 365-nm) simultaneously outputs UV light within a narrow wavelength range (365 ± 5 nm) into a 400 micron fiber-optic cable, which is output at the exit of the print head. Conversion of the reaction is controlled through modulating UV dosage such that the reaction is occurring in a continuous manner, i.e. reactant that emerges is reacting within itself but also reacting with material that has already been printed.