An Ultrasound-Integrated Microfluidic Platform to Enhance Intracellular Molecular Delivery

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Abstract

Cell therapies often require intracellular delivery of plasmids or other compounds to transform the cells for therapeutic effect. However, there are safety concerns with viral approaches and non-viral transfection techniques are generally slow and inefficient. To address this unmet need, we are developing a unique ultrasound-integrated microfluidic platform for rapid delivery of molecular compounds into cells. Ultrasound and microbubbles can be utilized to transiently permeabilize cell membranes for rapid intracellular delivery of molecular compounds. Therefore, we have assembled portable, cost-effective prototypes which integrate ultrasound transducers, a PDMS-based microfluidic device, and an Arduino controller inside a 3-D printed PLA case (Fig. 1). The PDMS-based microfluidic devices were fabricated with channel widths of 500 µm using standard photolithography techniques at the UofL Micro/Nano Technology Center. Piezoelectric ceramic discs (PZT, 1 cm diameter) were attached to microfluidic devices to continuously transmit 8-MHz ultrasound waves. Experiments were performed to assess ultrasound-mediated loading of a fluorescent dye (fluorescein) in human blood cells and cancer cells obtained from commercial vendors. Ultrasound treatment of cells in the microfluidic system significantly increased fluorescence, indicating that this approach can enhance intracellular delivery. This platform may potentially lead to more efficient delivery of plasmids and other compounds for cell-based therapies.

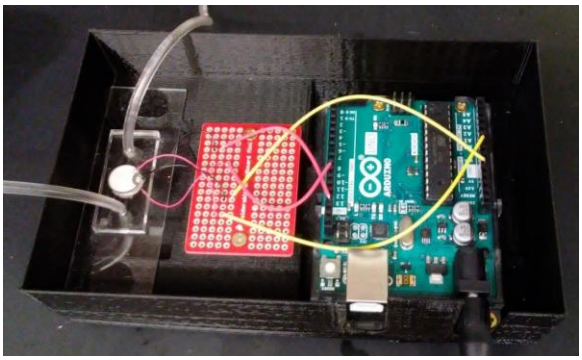

Figure 1: Prototype system for ultrasound-mediated molecular delivery to cells in a microfluidic device.

Biography of Presenter

Jonathan Kopechek is an Assistant Professor of Bioengineering at the University of Louisville. He joined UofL in 2016 after completing postdoctoral training at Boston University and the University of Pittsburgh. He obtained a Ph.D. in Biomedical Engineering from the University of Cincinnati in 2011. His overall research focus is the development of technology for ultrasound-targeted drug and gene delivery. His research program has been supported by funding from the National Institutes of Health, the National Science Foundation, and the American Heart Association.