Microfluidic Devices for High-Throughput Directed Evolution of Microbes for Rare Earth Element Purifications

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Primary CNF Tools Used: Heidelberg Mask Writer - DWL2000, ABM Contact Aligner, MVD100, Hamatech Hot Piranha, Class II Photolithography Room

Abstract:

Rare earth elements (REE), consisting of the lanthanides (elements from lanthanum to lutetium) as well as scandium and yttrium, are important ingredients to many sustainable energy technologies such as magnets — found in hard drives, electric vehicles, and cell phones — room temperature superconductors, and high-efficiency lighting [1]. Current methods for extraction and purification of these elements, however, utilize environmentally harmful chemicals and have a substantial carbon footprint [2]. We aim to use biology to create a cleaner, environmentally sustainable REE purification process. It has been found that bacteria contain numerous sites on their membrane that have specificity for both REE over other elements and for certain REE over other REE [3,4]. We plan on mutagenizing the genome of *V. natriegens* and then doing high-throughput screening to find strains with changes to preference for certain REE over others. We are utilizing the CNF to build a microfluidic droplet generation and sorting device in order to carry out this high-throughput screening.

Summary of Research:

At the CNF, we used the Heidelberg Mask Writer - DWL2000 to create masks (see Figure 1 for the designs) of our droplet generator and droplet sorter based on the generator and sorter created by Mazutis, et al. [5]. Utilizing the Class II Photoresist room, the Hamatech Hot Piranha, the ABM Contact Aligner, and the MVD100, we used this mask to create a SU-8 mold that we could use to create PDMS devices.

After the creation of these PDMS devices, we bonded them to a glass slide and treated the channels with Aquapel to make them hydrophobic. We then verified that droplets could be formed with this device (Figure 2). We also verified that our bacteria could survive inside these droplets.

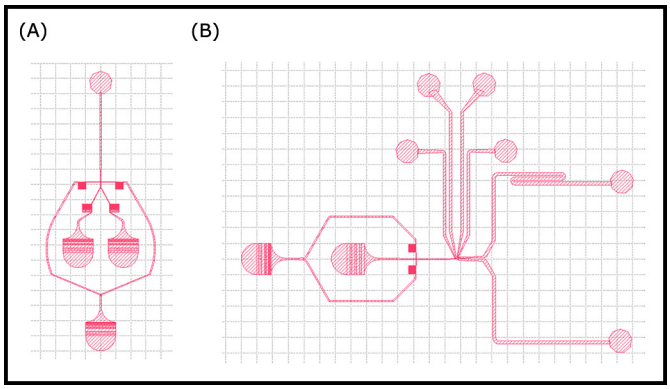

Figure 1: (A) Droplet generator design. (B) Droplet sorter design.

While we have yet to fully manufacture the sorting device we created at the CNF — which sorts via electrophoresis and requires the insertion of electrodes into two of the channels — we do have a sample of it created by a company that we were able to test. We verified that we could use this device to sort droplets generated by our device and that the bacteria were able to survive this sorting process that involves applying a square wave with an amplitude of 600-800 volts.

Conclusions and Future Steps:

Next steps involve integrating the device with an optical system so that we can sort the droplets based on the number of rare earth elements stuck to the bacterial membrane (we have a fluorescent protein that can help us with this). We also need to add electrodes to the sorting device we made at the CNF. Once these steps are done, we will be ready to use our device to select for mutagenized bacteria with membranes that have a preference for particular rare earth elements over others.

Figure 2: Droplets from droplet generator.

References:

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