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A High-Throughput, Multiplexed Microfluidic Method Utilizing an Optically Barcoded Drop Library

The power of drop-based microfluidics promises reduced biological assaying times and greater sample throughput; however, current drop-based microfluidic methods focus on single-input single-output techniques to provide these benefits. To achieve truly high-throughput analysis of biological assays, a multiple-input approach must be taken. The research presented here is focused on the development and validation of a drop-based microfluidic method that is capable of encapsulating, in parallel, 96 assay samples in drops and optically tracking them in a barcoded drop library. The advantage of such a method is its ability to be integrated with current biological assays performed on a 384-well plate. The first step was to fabricate a three-dimensional microfluidic device capable of accepting 96 sample inputs. Second, formation of drops within the device was characterized by creating a state diagram using Capillary and Weber numbers of the two-phase flow. Finally, the use of fluorescent microbeads was investigated for the purpose of optically barcoding drops. As a proof of concept, the microfluidic device was used to encapsulate 50 µm diameter drops from 24 wells barcoded with fluorescent microbeads at a drop formation rate of 3 kHz per well. Fluorescent detection of the barcoded drop mixture was performed at a rate of 200 Hz and density-based clustering algorithm DBSCAN was used to identify barcoded drop clusters from the fluorescent signal data. The results presented here show the microfluidic platform has the potential to be a useful tool in biological assays involved with tracking a large number of samples in a well-plate format.