MINIATURIZING THE LABORATORY IN EMULSION DROPLETS

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ABSTRACT

Programmable microfluidic modules have been created which can precisely make, combine, split, mix, incubate, detect fluorescence and fluorescence anisotropy, and sort microscopic droplets. All microdroplets are identical and stable, allowing for quantitative experiments, and sequential additions, which enables reactions to be started and stopped at defined times and reagents to be mixed in a combinatorial manner. Integration of multiple modules onto a single microfluidic chip enables a vast number of assays (>10^5 min^{-1}) to be performed using extremely low volumes of reagents. Each microdroplet functions as an independent microreactor separated from both the walls of the device and other microdroplets by a perfluorocarbon carrier fluid, in which non-fluorinated molecules are essentially insoluble and immiscible. We believe this technology has many applications, including high-throughput screening for drug discovery, next-generation DNA sequencing, on chip chemical synthesis, and protein engineering, including antibody engineering.

KEYWORDS: emulsions, modular unit operations, microreactors, multiplexing

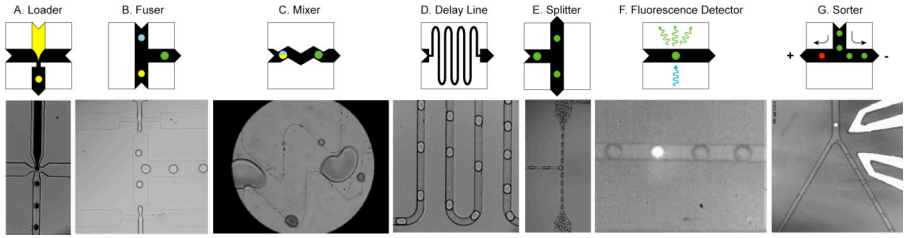

Figure 1. Microfluidic modules to manipulate microdroplets. A. Formation of highly uniform microdroplets (<1.5% polydispersity) at a frequency of 10^4 sec^{-1}; B. Fusion of droplets using an electric field; C. Rapid mixing (in msecs); D. Incubation in a delay line; E. Division (symmetric or asymmetric); F. Detection of fluorescence in microdroplets; G. Rapid sorting by applying an electric field at up to 10^4 sec^{-1}.

978-0-9798064-1-4/μTAS2008/$20©2008CBMS

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