Accurate and Rapid Micromixer for Integrated Microfluidic Devices
Tech ID: 21560 / UC Case 2008-249-0

SUMMARY

UCLA researchers have developed a novel micromixer to combine the advantages of precise droplet injection control typically achieved by elastomeric devices with the speed and space advantages typically achieved by droplet mixing.

BACKGROUND

Performing chemical reactions on the micro scale can drastically save costs by reducing reagent volumes needed. Mixing in microfluidics, however, is extremely difficult and, although many recent advances have been made, current methods for rapid mixing require careful tuning of flow rates and other parameters. Thorough and rapid mixing is essential in microfluidic reactions because it can achieve high and repeatable yields, eliminate side reactions (driven by temporary inhomogeneous reagent concentrations), and allow synthesis of molecules requiring reactants with very short half-lives (such as radiolabeling imaging probes). Especially for elastomeric valve-containing chips, stable droplet flow is rarely achieved at the very first droplet, wasting valuable reagents. The additional difficulty of knowing when stable flow has been reached also wastes reagents. Use of liquids with different viscosities, surface tension, hydrophobicity, or other physical properties further limits the accuracy of droplet size and ratios, especially for low volumes of at least one reagent. The ability to accurately control mixing volumes and ratios, but maintain rapid mixing would greatly improve the use of microfluidics to carry out chemical reactions using very small volumes.

INNOVATION

UCLA researchers have designed and created a novel mixer for microfluidic devices that combines the advantage of rapid mixing times of droplet-based mixers (typically found in continuous flow devices) with precision and accuracy for controlling mixing volumes and ratios. The chip consists of three components: a digital droplet generator, a droplet mixer, and a gas extractor. It has been designed to easily integrate into digital microfluidic chips, (i.e. chips that use valves to control fluid flow), as well as automated systems for a variety of applications.

APPLICATIONS

▶ Organic/inorganic syntheses of radiolabeling probes requiring reactants with short half-lives
▶ Couple to synthesis chip to achieve synthesis and biological labeling in a single set-up
▶ Automation of reaction condition optimization
▶ Mix a large number of reagents just by adding additional filling chambers
▶ Programmed generation of droplets of alternating composition
▶ Stop droplet flow for imaging analysis using valves

ADVANTAGES

▶ Valves permit simple integration with other microfluidic chips and automated systems
▶ Tremendous control over droplet sizes and reagent ratios, regardless of fluid properties
▶ Preserves reagents
▶ Precisely controlled droplet injection
▶ Proper mixing ratios assured from very first droplet
▶ Fast mixing, previously only characteristic of continuous flow systems
▶ Short mixing times reduces the use of valuable chip surface area
▶ Achieve mixing in a shorter distance than other droplet mixers
▶ Droplets can be mixed in a straight channel, simplifying fabrication
▶ Independently controlled parameters (fluid properties, volume, flow rates, pressure) during droplet generation
▶ Accurate, efficient, predictable, flexible
▶ Easily switch to different fluids
▶ Naturally fits to digital integrated microfluidic devices

STATE OF DEVELOPMENT

The researchers have created a detailed design and fabricated a working prototype. They have demonstrated the desired operation with their fabricated microfluidic chips and are devising fluorescence imaging to quantify parameters related to mixing. The inventors have also designed and are testing a new generation of the mixer to improve the initial design as well as further optimizing the chip for the best dimensions, droplet generation cycle times, and flow rates. The researchers have also built an interface between the mixing chip and a semi-automated chemical synthesis unit to synthesize a radioactive...
labeling probe and immediately label a biological molecule of interest.

**PATENT STATUS**

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**ADDITIONAL TECHNOLOGIES BY THESE INVENTORS**

- Device and Method for Microscale Chemical Reactions
- Microscale Device and Method for Purification of Radiopharmaceuticals
- Novel Method of Radiofluorination
- Digital Microfluidic Platform for Radiochemistry
- Method for Concentration and Formulation of Radiopharmaceuticals
- Device and Method for Accurate Sample Injection in Analytical Chemistry
- Disposable World-to-Chip Interface for Digital Microfluidics