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LAB-ON-A-CHIP

CHEMISTRY FLOWS LIKE CLOCKWORK

Flow system used to make simple devices for time-dependent studies

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A new method for controlling tiny quantities of reactants may help miniature chemical systems take a big step forward. Researchers in Chicago have devised a procedure that overcomes key problems that have limited development of lab-on-a-chip-type devices and other applications based on microfluidics (the flow of minute streams of fluids through narrow channels).

Motivated by potential advantages in cost, throughput, and automation, scientists have been developing miniature devices for chemical and biological analysis and rapid synthesis. One proposed system would blend multiple reagent streams within a device's narrow channels in a precise way, such that the distance traveled by the combined stream would be directly related to the duration of the reaction between the components. That type of system could be used to follow the evolution of a reaction, to probe reaction kinetics, and to make time-resolved measurements.

Designing such a device, however, has remained challenging because side-by-side streams in microfluidic systems flow in a laminar fashion--they remain parallel and don't mix much. Also, friction between the channel walls and the fluids disperses the reagents, disturbing the relationship between travel distance and reaction time. Although some techniques force laminar streams to mix, they don't avoid the dispersion problem.

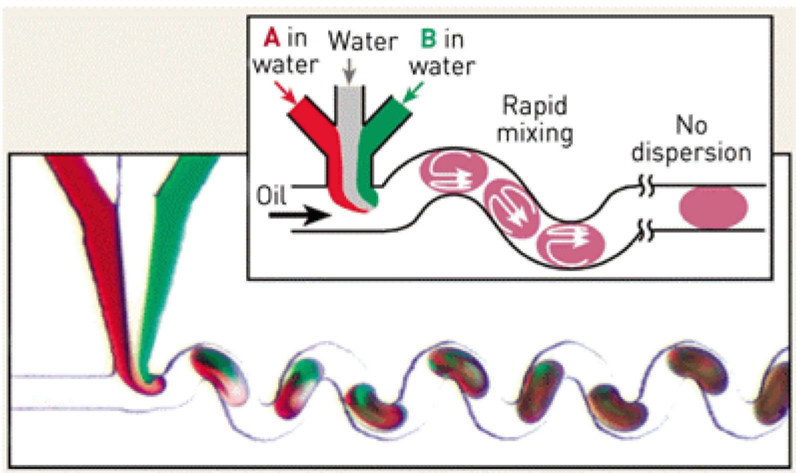
But now, University of Chicago assistant chemistry professor

Rustem F. Ismagilov, graduate student Helen Song, and Joshua D. Tice, an undergraduate student, have designed a microfluidic flow system that simultaneously transports and mixes solutions but doesn't disperse them [*Angew. Chem. Int. Ed.*, **42,** 768 (2003)].

Demonstrating the new procedure, the group used syringe pumps to deliver several solutions to a micrometer-sized winding microchannel system with multiple inlets. By coordinating the flow of two distinctly colored aqueous reagent solutions, an aqueous "separating" solution, and perfluorodecaline, a water-immiscible fluid, the team caused the reagents to blend and break up into 500-pL droplets that flowed single file down the channel. Forces acting on the droplets generate chaotic flows in the interior of the tiny volumes, leading to efficient and rapid mixing without dispersing the droplets. Mixing of the colored solutions was monitored with microphotography.

In related work, the chemists showed that the flow system can be used to measure reaction rates on the millisecond timescale. Specifically, they used a fluorescence method to monitor the extent of calcium binding to a fluorescent dye.

The flow system is easy to fabricate and operate and has no moving parts, the researchers stress. In addition, they say that, aside from the inexpensive plastic chip into which microchannels are patterned lithographically, the technique calls for standard laboratory equipment.



GO WITH THE FLOW **Controlled delivery of one oil and three aqueous solutions into a winding microfluidic channel causes green and red reagent solutions to blend and separate into**

microscopic droplets, which facilitate rapidmixing (color changes in milliseconds) but don't disperse.
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