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Microfluidics

Plugging Along

Design advances improve spatial and temporal resolution of plug-based devices

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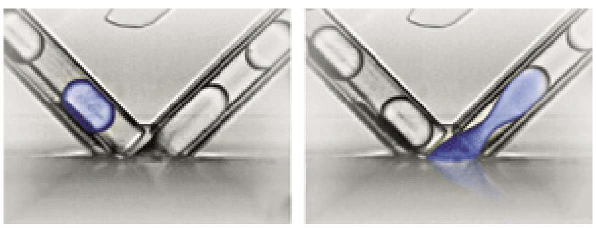
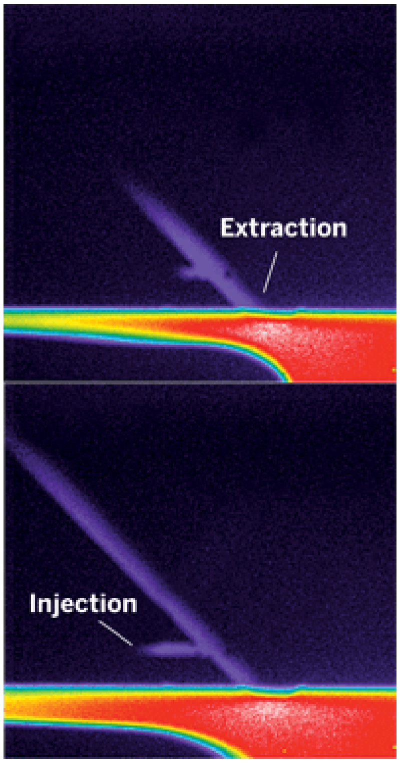


Courtesy of Rustem Ismagilov
Droplets The chemistrode delivers (left) and picks up (right) solvent plugs at a surface.

TWO RESEARCH GROUPS report new device designs that improve the speed and spatial resolution of plug-based microfluidic analysis.

Plug-based microfluidic devices use aqueous solvent droplets, or plugs, in an oil stream to deliver reagents and transport samples. In these devices, samples contained in plugs do not easily disperse or mix with adjacent samples, but the new designs improve the performance of such systems still further.

In one of the studies, Rustem F. Ismagilov and coworkers at the University of Chicago report a new plug-based microfluidic device that they call a "chemistrode" (*Proc. Natl. Acad. Sci. USA,* DOI: 10.1073/pnas.0807916105).



Courtesy of Robert Kennedy

Rapid Fire In a "virtual wall" device, a sample is rapidly extracted from an aqueous plug in the segmented flow channel and injected into an electrophoresis channel in less than 0.3 seconds.

The chemistrode, which is V-shaped polymeric tubing threaded through a microfabricated holder, can deliver reagents in aqueous plugs to a precisely defined location on a surface and capture plugs of molecular signals generated in response to those reagents. Reagent plugs travel through one arm of the V, and response plugs are picked up by the other. The response plugs can be split and diverted for parallel analysis by multiple methods. And with a single device, one can see what happens at different positions on a surface; for example, the researchers constructed a device with two chemistrodes spaced 15 µm apart.

"We can essentially stick this device onto a point on a surface and say 'I want these chemicals to be delivered to thi spot in this sequence' and then read out the responses," Ismagilov says. His team demonstrated the device by detecting insulin secretion from pancreatic islet cells in response to changes in glucose concentration.

The work is a "clever and elegant application of droplet microfluidics" says Daniel T. Chiu, a chemistry professor at the University of Washington who also works with droplet microfluidics. "This method will find broad use in studying secretions from cells."

Separately, Robert T. Kennedy and coworkers at the University of Michigan enhance microfluidic analysis with a new device that uses a "virtual wall"—an interface between parallel streams of aqueous buffer and a fluorocarbon oil—to collect aqueous sample droplets for analysis (*Anal. Chem.,* DOI: 10.1021/ac801317t). The oil medium transports the droplets from a sample source. At a point of contact, sample droplets transfer from the oil stream to the aqueous stream, where they can be analyzed electrophoretically.

The design makes possible two types of "injectors" for sample transfer prior to electrophoresis: a "discrete injector" and a "desegmenting injector." The discrete injector extracts sample from individual plugs as they pass, enabling sampling of more than 800 individual plugs in a row. With the desegmenting injector, the plugs recombine into a continuous stream that can be monitored by up to 1,000 sequential injections into an electrophoresis channel.

The discrete injector is useful for applications such as high-throughput screening, in which each droplet is treated a: a separate sample. And the desegmenting injector works well for applications that don't require every droplet to be analyzed, such as microdialysis.

"Kennedy's team has introduced two powerful tools for analyzing the contents of individual droplets in segmented flows," says Robin L. Garrell, who studies microfluidics at UCLA. "By being able to desegment the flow, it's now possible to examine the composition of droplets over time, a valuable tool for monitoring reactions and for microdialysis sampling."

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