ANALYTICAL CURRENTS

Detecting water toxins

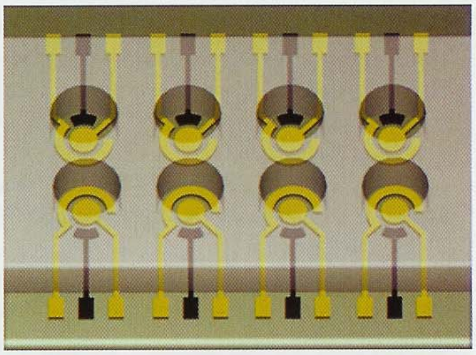
Rachela Popovtzer and colleagues at Tel Aviv University (Israel) have designed an electrochemical biochip for the detection of toxins in water. The chip produces a signal within 10 min of exposure to toxins of various concentrations.

The device consists of two parts. One part is reusable and is interfaced with the electronic circuitry. The other part is disposable, with an array of nanosized chambers. The array format allows the simultaneous investigation of eight different toxins or toxin concentrations.

The chambers contain genetically modified *E. coli* bacteria that behave as the sensing element in the chip. When exposed to toxins in water, the bacteria produce the enzyme β-galactosidase in response to the stress. The enzyme breaks down a substrate called *p*-aminophenyl β-D-galactopyranoside to produce *p*-aminophenol (PAP). PAP is oxidized at an electrode held at 220 mV, and the oxidation current is monitored.

The investigators used the chip to analyze the environmental toxins ethanol and phenol. They found a direct correlation between the signal generated from the PAP oxidation and the toxin concentration. The system could detect concentrations as low as 0.5% ethanol and 1.6 ppm of phenol.

Popovtzer and colleagues say the advantage of the system is that the bacteria can amplify their signal as the environmental stress increases; the assay doesn't wait for the cells to lose their viability and die. The assay can even be performed with turbid solutions and under anaerobic conditions. (*Nano Lett.* **2005**, *5*, 1023–1027)



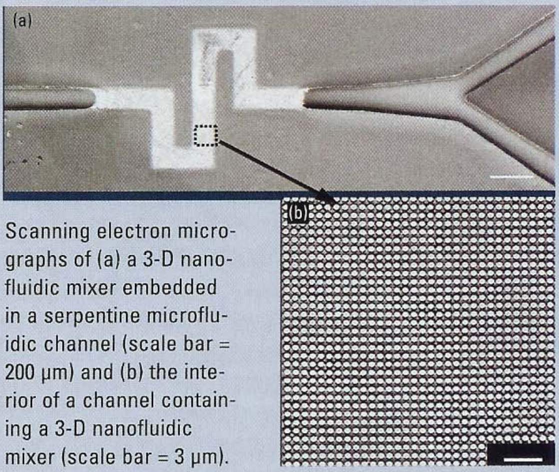
A chip with eight miniature electrochemical cells, each with a 100-nL capacity, monitors signals generated by bacteria upon exposure to water toxins.

Mix it up in 3-D

Using a photolithographic technique called proximity field nanopatterning (PnP), John Rogers and colleagues at the University of Illinois at Urbana–Champaign have generated well-defined 3-D nanostructures that enhance mixing in microfluidic channels. When incorporated into microfluidic devices, the nanostructures function as efficient passive mixers, especially at low Reynolds numbers.

To create the nanostructures, the researchers shine UV light through a conformable PDMS PnP mask, which rests on top of microfluidic channels. The mask contains a square array of posts, which are 570 nm in diameter, 420 nm high, and spaced 710 nm apart. The optics of the mask are analyzed with near-field scanning optical microscopy, which provides intensity information along and away from the surface.

Rogers and colleagues generated devices with three different mixer geometries: a 90° serpentine channel, a 60° serpentine channel, and a straight channel. They also fabricated a control channel without a mixer. To evaluate the efficiencies of the mixers, they pumped water and a fluorescent solution through the channels and analyzed cross-sectional confocal images taken at the ends of the mixers. At low flow rates, mixing was efficient for all four channels. As the flow rates increased, the efficiency of the control channel dropped more quickly than did those of the mixers. The mixer geometries with bends were more efficient than the straight channel. (*Nano Lett.* **2005**, doi 10.1021/nl050606r)



Scanning electron micrographs of (a) a 3-D nanofluidic mixer embedded in a serpentine microfluidic channel (scale bar = 200 μm) and (b) the interior of a channel containing a 3-D nanofluidic mixer (scale bar = 3 μm).