Reports from Other Journals

Research Advances

Catch and Release; Mini Mass Spectrometer; Drug Delivery by Magnetic Propulsion

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Cutting edge research can be done on a small scale, literally. This month's *Research Advances* focuses on innovations that come in small sizes.

Microscopic "Hands" for Building Tomorrow's Machines

In a finding straight out of science fiction, chemical and biomolecular engineers in Maryland are describing development of microscopic, chemically triggered robotic "hands" that can pick up and move small objects. They could be used in laboratory-on-a-chip applications, reconfigurable microfluidic systems, and micromanufacturing, the researchers say.

In this new study, David Gracias and colleagues at Johns Hopkins University note that researchers have long sought to develop chemically triggered microscopic devices that can manipulate small objects with precision. Chemical actuation occurs in biological machinery and enables autonomous function in nature with high specificity and selectivity. Although other scientists have made experimental "grippers" in the lab, these devices generally require the use of batteries and wiring, making them hard to miniaturize and maneuver in small spaces and convoluted conduits.

The researchers describe development of tiny metallic microgrippers shaped like hands that work without electricity (Figure 1). The grippers are about 0.0762 cm wide when open—smaller than the diameter of a grain of sand—and made from a gold-coated nickel "palm" joined by six pointy metallic "fingers" made from layers of Cr, Cu, and a photopatternable polymeric resin. Because Ni is ferromagnetic, the grippers can be moved from distances up to several cm away with a magnet.

The addition of certain chemicals triggers the hands to open or close. When prepared, the grippers remain flat until acetic acid is added to the solution. At that point the gripper closes because the polymer layer dissolves; the gripper remains closed until the Cu layer is dissolved by adding hydrogen peroxide. In laboratory studies, the scientists demonstrated that the grippers could grasp and release tiny pipes and glass beads and transport these

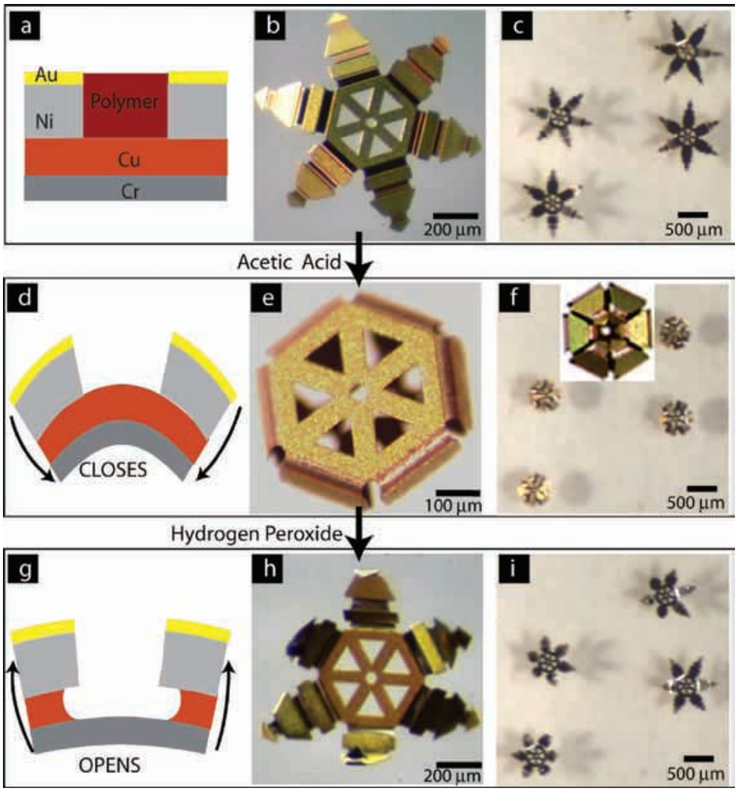

Figure 1. Opening and closing of microgrippers:

(a) Schematic diagram of the trilayer hinge joint between two Au-coated Ni phalanges. Optical microscopy image of (b) a single microgripper, and (c) many microgrippers in water.

(d) Schematic diagram of the microgripper closing when acetic acid dissolves the polymer layer within the hinge. Optical microscopy image of (e) a single microgripper and (f) many microgrippers closing on addition of acetic acid (inset shows the view from the bottom of a closed microgripper).

(g) Schematic diagram of the microgripper opening when H_2O_2 dissolves the Cu layer within the hinge. Optical microscopy image of (h) a single microgripper, and (i) many microgrippers opening upon addition of H_2O_2.

Image credit: American Chemical Society.

objects to distant locations with the aid of a magnet, showcasing their potential for pick-and-place operations that are ubiquitous in manufacturing, the researchers report. Additional work has revealed biomedical applications, with the microgrippers removing cells from tissue in an in vitro biopsy (Figure 2).

Gracias and colleagues state that this demonstration is also a step toward the development of Micro Chemo Mechanical Systems (MCMS) in contrast to the already well-established field of Micro Electro Mechanical Systems (MEMS); the main difference between them is that the MCMS tools are triggered by chemistry rather than electricity in MEMS.

More Information

1. Randhawa, J. S.; Leong, T. G.; Bassik, N.; Benson, B. R.; Jochmans, M. T.; Gracias, D. H. Pick-and-Place Using Chemically Actuated Microgrippers. *J. Am. Chem. Soc.* **2008,** *130*, 17238–17239.

2. Gracias's research is described at *http://www.jhu.edu/chembe/gracias/* (accessed Oct 2009).

3. For details on how this research has been applied to biological biopsies, see Leong et al., *Proc. Nat. Acad. Sci.* **2009,** *106*, 703–708.

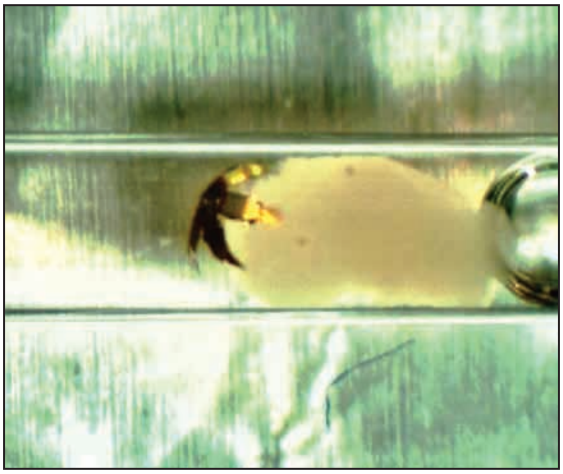

Figure 2. In this optical video snapshot, a tetherless microgripper grabs a clump of live cells placed at the end of a narrow glass capillary tube. (Image credit: T. G. Leong and C. L. Randall, Johns Hopkins University.)

"Micro"-Sized Mass Spectrometer

Researchers in Indiana are describing development of the world's smallest complete mass spectrometer, a miniature version of the standard lab device—some of which would dominate a living room—to identify tiny amounts of chemicals in the environment. The handheld MS device, about the size of a shoebox, could speed the detection of bioterrorism agents, hidden explosives, and other threats, the researchers report.

R. Graham Cooks, Zheng Ouyang, and colleagues at Purdue University note that scientists have developed several different versions of portable mass spectrometers over the past few decades. However, the instruments' large size, weight, and inability to analyze a wide variety of different target molecules have limited their practical use.

The scientists responded to the need for a small yet sensitive MS instrument by developing the Mini 11 (Figure 3). Including the batteries, the Mini 11 weighs only 9 pounds (half the weight of other portable MS devices) and can be operated by remote control. It can be coupled to a variety of ionization sources through a capillary interface and has detection limits in the parts-per-billion range. Lab tests showed that the Mini 11 could accurately identify the chemical composition of three commonly used commercial drugs (aspirin, Claritin, and Excedrin) within just one minute using tandem MS, and test trials also successfully analyzed ink from common pens. Unlike previous portable MS devices, this new instrument is capable of analyzing a wider variety of molecules, including large proteins with a m/z of up to 1500 Da/z, the scientists state.

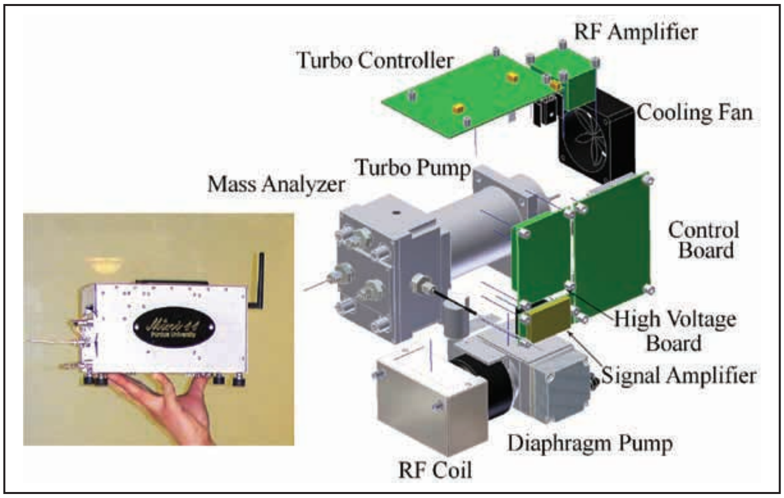

Figure 3. Chemists have developed the world's smallest mass spectrometer, the Mini 11, which could be used to detect hidden explosives or bioterrorism agents. Image credit: American Chemical Society.