Vibrating Paddle Oscillator Senses the Mass of a Virus

Device could differentiate among a wide variety of pathogens.

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By using a device only six-millionths of a meter long, researchers at Cornell have been able to detect the presence of as few as a half-dozen viruses. They believe the device is sensitive enough to notice just one. The experiment is an extension of earlier work in which similar devices were used to detect the mass of a single bacterium.

COMMERCIAL APPLICATIONS

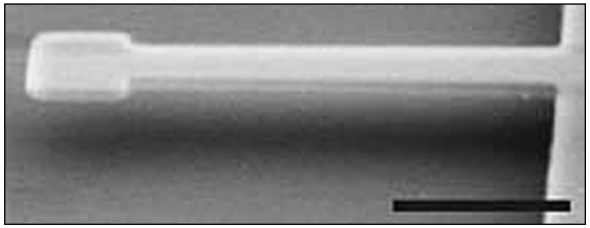
- **Individual organic molecule detectors**

The research could lead to simple detectors capable of differentiating among a wide variety of pathogens, including viruses, bacteria, and toxic organic chemicals.

Arrays were created of tiny silicon paddles from 6 to 10 micrometers (millionths of a meter) long, half a micrometer wide, and about 150 nanometers (billionths of a meter) thick with a 1-micrometer square pad at the end. A large array of paddles was mounted on a piezoelectric crystal that can be made to vibrate at frequencies on the order of 5 to 10 mHz. The experimenters then varied the frequency of vibration of the crystal. When it matched the paddles' resonant frequency, the paddles began to vibrate, as measured by focusing a laser on the paddles and noting the change in reflected light, a process called optical interferometry.

The natural resonant frequency at which something vibrates depends on, among other things, its mass. A single one of these silicon paddles weighs about 1.2 picograms and vibrates at an approximate frequency of 10 mHz. The virus used in the experiment weighs about 1.5 femtograms. (A picogram is 1/1,000,000,000,000th of a gram and a femtogram is 1/1,000th of a picogram.) Adding just a few virus particles to a paddle turns out to be enough to change its resonant frequency by about 10 kHz, which is easily observable.

To trap viruses, the paddles were coated with antibodies specific to *Autographa californica* nuclear polyhedrosis virus, a nonpathogenic insect baculovirus widely used in research. The paddle arrays were then bathed in a solution containing the virus, causing virus particles to adhere to the antibodies. Because air damps the vibration and greatly reduces the selectivity of the system, the treated paddles were placed in a vacuum for testing. From the frequency shift of about 10 kHz, the researchers calculated that an average of about six virus particles had adhered to each paddle. According to the researchers, it might be possible to demonstrate detection of single particles by further diluting the virus solution. The system also can differentiate among various virus concentrations.



This is a scanning electron micrograph of a **Cantilever Oscillator** measuring 6 micrometers long, 0.5 micrometers wide, and 150 nanometers thick, with a 1-micrometer square paddle. The scale bar corresponds to 2 micrometers. (*Photo courtesy of C. Drew Harvell*)

As expected, the smallest paddles were the most sensitive. It was calculated that the minimum detectable mass for a 6-micrometer paddle would be 0.41 attograms (an attogram is 1/1,000th of a femtogram.) This opens the possibility that the method could be used to detect individual organic molecules, such as DNA or proteins.

This work was performed by Harold Craighead, Rob Ilic, Yanou Yang, Michael Shuler, and Gary Blissard of Cornell University. Visit the Craighead Research Group at ***www.hgc.cornell.edu/index.html***.