Single-cell sensitive biological sensor works in liquid

November 26 2007

Microscopic, magnetized balls of Styrofoam have been turned into inexpensive biological sensors in a University of Michigan laboratory.

They're so sensitive they can detect a single bacterial cell. And they work in liquid, which has been a tough medium to crack for such sensitive, quick-acting biological sensors.

"There are a lot of efforts to do single cell detection with this type of sensor because of biological warfare and superbugs. But most of those are operated in air or vacuum environments. No one is really succeeding in liquids. But most biologically interesting samples are in liquids—sputum and blood, for example," said Brandon McNaughton, a physics post-doctoral researcher. McNaughton is first author of a paper on the research to be published in the Nov. 26 issue of *Applied Physics Letters*.

Their ultimate goal is to develop a device that doctors could use to identify bacteria and to test whether and how fast an antibiotic kills a particular bacteria.

The new method exploits the drag force that solids experience in fluids. Drag is the friction that slows objects when they try to move through a gas or a liquid.

The magnetized Styrofoam spheres used in the new method are commercially available. McNaughton and his colleagues coated them

with antibodies that would attach to bacteria and then immersed them in a solution containing bacteria.

The magnetism of the spheres plays no part in attracting the bacteria. It makes the mechanics of the system work. A relatively larger magnet, a cube smaller than a Tic-Tac mint, rotates outside the solution, causing the magnetized spheres in the solution to rotate as well.

The larger magnet rotates fast enough that an "asynchronous rotation rate" is established between the microspheres and the larger magnet. That means the rotations aren't quite in synch with one another, making the tiny spheres more sensitive to drag. So when a bacterium attaches to the antibodies on the sphere, the sphere's rotation slows dramatically.

"The period of rotation increases by 280 percent when you add a bacterium," said Raoul Kopelman, a professor of chemistry, physics and biomedical engineering who is also an author of the paper. The period of rotation is the amount of time it takes to make one full rotation.

It slows more if an additional bacterium attaches or even if the attached bacterium grows.

This approach is "label free," the scientists say. Often, when scientists seek to detect and monitor bacterial cells, they must label the cells with a dye. McNaughton, Kopelman and their colleagues used dye in the experiment to verify that attached bacteria were causing the slowing rotations of the spheres. But it isn't necessary for standard operation.

The paper is called, "Single bacterial cell detection with nonlinear rotational frequency shifts of driven magnetic microspheres."

Kopelman is the Richard Smalley Distinguished University Professor of Chemistry, Physics and Applied Physics and a professor of biomedical

engineering and biophysics.

Source: University of Michigan