Magnetism and mimicry of nature hold hope for better medicine, environmental safety

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Critical advances in medicine and environmental protection promise to emerge from a new method for biochemical analysis of fluids developed by an international science team led in part by Arizona State University researchers.

Called "digital magnetofluidics," it promises more rapid, more accurate and less costly analyses of water and biological fluids – blood, urine, saliva – that require only miniscule amounts of fluids.

A detailed explanation of the process is presented in an article published in the July 17 edition of *Applied Physics Letters*, a leading international journal reporting on significant new findings in physics applied to engineering, technology and other sciences. The article, "Discrete Magnetic Microfluidics," can be viewed online at http://apl.aip.org/.

Digital magnetofluidics enables tiny drops of fluids to be manipulated on a silicon chip in ways that produce clearer pictures of the proteins, DNA, bacteria, viruses and chemicals present in liquids, explains Antonio Garcia, a professor in the Harrington Department of Bioengineering in ASU's Ira A. Fulton School of Engineering.

The new method holds hope for significant improvements in such areas as prognosis and diagnosis of medical conditions and in testing of water sources for environmental hazards, Garcia said.

At ASU, Garcia is among scientists and engineers developing microfluidic and test-surface techniques. The team includes Mark Hayes and Devens Gust, both professors of chemistry and biochemistry, and Tom Picraux, who spent the past four years on the ASU chemical and materials engineering faculty before recently becoming chief scientist for the Center for Integrated Nanotechnologies at the Los Alamos National Lab in New Mexico.

They were aided by ASU postdoctoral research fellow Solitaire Lindsay and graduate students Dongqing Yang, Pavan Aella and Ana Egatz-Gomez.

The ASU group's work is part of the international effort by the Interdisciplinary Network of Emerging Science and Technology (INEST), directed by Manuel Marquez, an adjunct professor of bioengineering at ASU. He and Lindsay are affiliated with the INEST group research center in Richmond, Va., supported by the Philip Morris USA company.

Marquez, and fellow researchers in Spain, including professors Sonia Melle at Universidad Complutense de Madrid and Miguel Angel Rubio, and graduate student Pablo Dominquez-Garcia at Universidad Nacional de Educacion por Distancia, who have produced the first demonstration of the new technology, are an integral part of the microfluidics project.

The team's findings could have a vast impact on the field of bioanalysis, Hayes says.

The key to the method's effectiveness is using nanoscale surface patterns to create a "superhydrophobic" (or water-repellent) surface on which to collect extremely tiny droplets of fluids – a surface formed by mimicking the natural self-cleaning process exhibited by the leaves of the Lotus plant, Hayes explains.

Water and biological fluids typically bead up like a ball on superhydrophobic surfaces, but the introduction of a magnetic field produced by injecting tiny magnetic particles into the droplets keeps the ball from rolling off the surface.

This allows for the fluids to be controlled through exerting magnetic force, and moved with extreme precision across the tips of nanowires, which are only about 200 atoms in diameter and less than a hundredth of the width of a human hair in length.

"We knew we had the perfect surface on which to analyze drops of blood and other biological fluids because the trapped air between the wires never allows for much of the fluid to come into contact with the surface," Garcia says.

That is crucial to accurate analysis because it prevents the chemicals and other materials in the droplet from combining and reacting with the chemical compounds in the surface material and thereby contaminating the test sample of fluid.

The process is the crux of what the researchers call "lab on a chip" technology, which will enable scientists, health care professionals and environmental experts to obtain precise biochemical test results with only micro-level amounts of fluids.

"By manipulating droplets so carefully and preventing contamination of the samples, we can detect things like signs of disease or environmentally hazardous materials much better," said research associate Lindsay. "We can analyze things using small droplets that normally would require much larger amounts of fluid for testing. This reduces the expense of testing because you don't need large amounts of very expensive chemicals to do the analyses."

Perhaps the most critically important thing the method will help save is time, especially in medical diagnoses. "You might be able to get an analysis of someone's health condition in 15 minutes rather than having it take two days," says Picraux.

Digital magnetofluidics will allow for more compact and portable testing instruments that will work fast and require less power to operate, he says.

It also holds promise for improving public safety and homeland security efforts, Picraux says. The method could aid in more quickly and accurately detecting and analyzing dangerous chemicals if they were intentionally introduced into a public environment. It also could improve monitoring systems in factories and other industrial operations where potentially hazardous chemicals are in use.

The research can accelerate the development of microfluidic devices that would, for instance, allow as many as 20 to 30 various tests to be performed using a single, tiny drop of blood.

A major goal is to refine the technology to create point-of-care devices that would provide rapid diagnoses for people who live far from hospitals, or in cases of emergency medical care in which there is an urgent need for speedy medical analysis.

Such technologies can also give the pharmaceutical industry improved ways to screen for new drugs by being able to run several types of tests simultaneously on an extremely small scale.

The next step in developing this technology is under way in Hayes' laboratory and through the team's collaboration with Joseph Wang, a professor in the Fulton School's Department of Chemical Engineering.

Wang's research group at ASU's Biodesign Institute is developing complementary electrical analysis methods and Hayes is applying optical strategies to rapidly measure amounts of significant biochemicals and proteins. The measurement of dopamine and other biological indicators of stress and acute indicators of heart attacks are of particular interest to medical research.

Source: Arizona State University

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