Laser Goes Tubing for Faster Body-Fluid Tests

April 2 2007

University of Rochester researchers announce in the current issue of *Applied Optics* a technique that in 60 seconds or less measures multiple chemicals in body fluids, using a laser, white light, and a reflective tube. The technique tests urine and blood serum for common chemicals important to monitoring and treatment of diabetes and cardiovascular, kidney, urinary and other diseases, and lends itself to the development of fast batch testing in hospitals and other clinical settings.

Co-researchers Andrew J. Berger, associate professor of optics, and Dahu Qi, doctoral candidate, used low-refractive-index tubes instead of cuvettes or other bulky containers for holding biological specimens. And, to get more information from the fluids, they used white light—like that from an ordinary light bulb—along with the laser. The tubes and light bulbs made all the difference.

In the laser technique called Raman spectroscopy, scientists shine laser light onto molecules and the light scatters off, gaining or losing energy. A spectrograph translates the changed energies into spectra. Each chemical presents a Raman spectrum that scientists recognize. The Raman approach is a favorite for finding chemicals that overlap and mix in fluid, much like musical instruments in an orchestra. But Raman spectroscopy comes with a problem.

Raman signal is notoriously weak. Using it to test biofluids, with their lighter chemical concentrations than in many fluids, is not a natural choice. Berger and Qi injected fluid samples into a thin transparent tube

specially made to contain the light, and the tube's long path length of interaction let the scientists collect more Raman scattering. "The tubes have a refractive index lower than water, so the light bounces along inside the liquid core, just as in solid optical fibers for telecommunications," said Berger. "Other groups had used these fibers to strengthen their Raman signals, so we wanted to see if we could translate that advantage to use with biofluids."

They did get the stronger signal they were looking for, but the increase threw off measurements when samples of urine or blood serum varied in color.

In previous experiments, Berger and his team had explored how a concentration of each chemical relates to the strength of Raman signal. It turned out the relationship is not a simple linear one. They were able to use that information for dealing with differences in sample color.

"We can't neglect that body fluid samples absorb light," said Berger. "We'd have two different samples with the same amount of protein and not get the same strength of signal. If we had two samples of blood serum, maybe one sample would be a little pinker due to a few ruptured red blood cells. Then we wouldn't get the same signal strength."

The solution flashed like a light bulb. The scientists sent a beam of white light through each sample to see how much light was absorbed at various wavelengths, and then they calculated corrections. It was easy enough to inject the light by using the end of the tube opposite the laser. The resulting corrections made chemical predictions significantly more accurate.

The team measured 11 chemicals in blood serum, including total protein, cholesterol, LDL and HDL levels, glucose, triglyceride, albumin, bilirubin, blood urea nitrogen, globulin, and CO2. In urine, they

identified urea nitrogen and creatinine. The technique does not measure ions such as calcium or sodium, or other chemicals present at concentrations below about 0.01 mg/mL.

Spectral tests use no chemical reagents and therefore offer the advantage of being nondestructive to fluid samples, unlike many lab tests. After analysis, practitioners could use undamaged samples for other kinds of tests.

"We squeeze a small amount of fluid into the tube," said Berger. "In 10 or 20 seconds, we have a chemical breakdown, and we can see the presence of a lot of chemicals all at once. There's no chemistry performed, and there's no touching of the fluid."

The tubing doesn't just help with the signal strength; it also makes it easy to move biofluids around. "We pump a sample into the tube, pass some light through it, and send it along its way—and then we're all set to pump in the next one," said Berger.

Source: University of Rochester