‘Mini-rivers’ may detect explosives, toxins better than other types of sensors

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A casual conversation between two professors on a train from Oxford to London has led to the development of a new type of sensor that may be markedly better at sniffing out explosives, cocaine or environmental toxins than sensors now on the market.

The professors, Juan G. Santiago of Stanford University and Carl Meinhart of the University of California-Santa Barbara, both associate professors of mechanical engineering, had been at the University of Oxford for a conference. On the train, they were talking about their common interest, a type of spectroscopy that involves the precise control of tiny streams of water running through a glass tube no wider than a human hair.

The spectroscopy makes it possible to identify an unknown substance by dissolving the substance in water and then flashing it with laser light as it flows through the tube. The molecules of the mystery substance respond with a spray of photons whose frequency "signature" gives away their identity.

As the English countryside flashed by outside the train windows, the talk between the researchers turned to their recent refinement: running the mini-rivers through a miniature open-air canal instead of the glass tube. Santiago suggested that by exposing the water to the atmosphere in this fashion, the device might work as a detector rather than a laboratory instrument. Random molecules of the gases in the surrounding air would strike the water surface and be absorbed, making it possible to identify

them. Meinhart understood the significance: "We were sitting on the train, and I said, 'Oh, I know how to do that.'"

After more work by the two professors and their graduate students, they have formed a company to take the detector to market. The company, SpectraFluidics, has filed for patents. "The new thing is that you can have this interaction occur in real time," Santiago said. "As you're controlling the liquid, it's being exposed to the atmosphere." Detection of a specific substance might take only two or three seconds, much quicker than current detectors, the researchers said. They described their work in a paper to be published this week in the online version of the *Proceedings of the National Academy of Sciences*.

The basic technology behind the technology, known as "surface-enhanced Raman spectroscopy," has been in use for some time. The "enhancement" comes from seeding the water with, typically, gold or silver. Certain target molecules will aggregate on the gold or silver; for complex reasons, this makes the target molecules much easier to detect. "It's a huge enhancement," Santiago said. In fact, the molecules may be a trillion times easier to see. As a practical matter, this enhancement means a substance may be detected if there are only a handful of molecules in the water.

Santiago and Meinhart are exploring methods to realize and control the flow of micro "rivers" in channels just a few microns deep. Meinhart has been driving the flows with pressure. Santiago is exploring the use of electric fields to switch on and off and divert these open channel streams.

The canal's interior is made with a hydrophilic material, while the area adjoining the canal is hydrophobic. "So the water wants to stay in there," Santiago said. Surface tension also helps keep the water in the channel; it stays put even when the device is turned upside down.

Meinhart predicts a handheld device in the near future and a much smaller model—an inch square, laser included—within five years. "We're not sure, but we think we're at least three orders of magnitude better than anything else that's out there for explosives," he said.

"If you had cocaine just sitting on a table, we could probably measure the evaporation coming off that, which is unheard of," he added. "It's an optical nose. We're using light to smell things only your dog can smell."

Also contributing to the paper, "Free-surface microfluidic control of surface-enhanced Raman spectroscopy for the optimized detection of airborne molecules," were Brian D. Piorek, Seung Joon Lee, Martin Moskovits and Sanjoy Banerjee of UC-Santa Barbara. The U.S. Army, U.S. Air Force and National Science Foundation funded this research.

Source: Stanford University