New technology uses smartphones and paper to analyze samples

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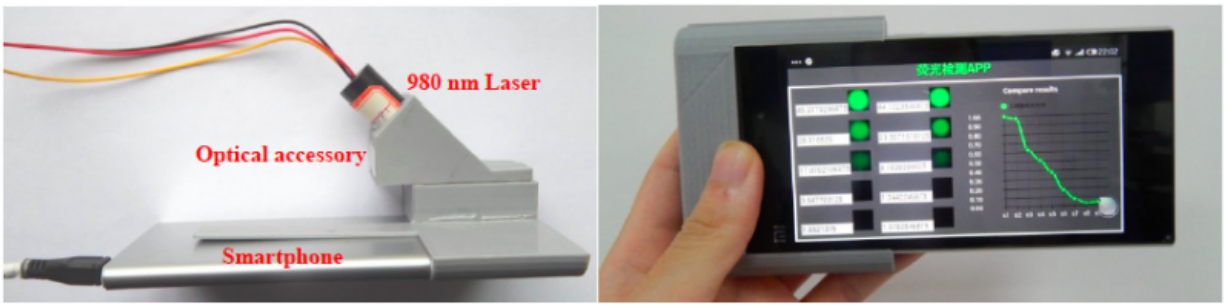

The prototype smartphone-based detection system – courtesy of Professor Mei et al., the images first appeared in the paper in *Biosensors and Bioelectronics*.

Paper sensors that can be analyzed using an Android program on a smartphone could be used to detect pesticides rapidly and cheaply, according to a new study published in *Biosensors and Bioelectronics*.

As the role of pesticides in the decline of pollinator populations and their potential effect on health becomes clearer, it is increasingly important to be able to detect them in the environment and on foods. Usually the equipment used to detect pesticides and other chemicals is large, expensive and slow, making on-the-spot detection challenging.

Smaller detectors have been developed using paper as a sensor material, but they have not produced strong enough signals for detection. The new

study, by researchers at Hefei University of Technology in China and the National University of Singapore, presents a portable smartphone-based detection system using a paper sensor that produces strong signals that can detect the pesticide thiram.

"Since detectors are usually big, it was important that we could develop a smaller unit that was powerful enough to detect small concentrations of the pesticide," said Prof. Qingsong Mei, one of the authors of the study from Hefei University of Technology in China.

"We're excited that this new detection system works to identify thiram, and we think we can develop it further to detect many different molecules in a sample," added Prof. Yong Zhang, a lead author of the study from the National University of Singapore.

To make the detector, the researchers had to develop three components: nanoparticles to detect the pesticide and emit a fluorescent signal on the paper, a 3D-printed piece of equipment made of a smartphone attached to a mini-laser, an optical filter and a mini-cavity, and a piece of software that runs on Android.

The nanoparticles - called upconversion nanocrystals - are decorated with copper ions and fixed onto the paper. A sample is then put on the paper, and pesticide molecules attach to the copper ions on the nanoparticles. The device shines a light onto the paper and, using the specially developed software, the smartphone reads the fluorescent light emitted from the nanoparticles.

The fluorescent light differs according to the amount of pesticide present in the sample, so the software can translate that signal into a concentration of pesticide. The system gives a reliable and accurate detection reading at low concentrations of 0.1 μM.

"This is one of the first prototyping systems that integrates a paper sensor like this with a smartphone, and it can be reused, making it economically even more favourable," said Prof. Bing Nan Li, a lead author of the study from Hefei University of Technology in China. "The smartphone is advantageous in terms of its portability, accessibility, programmability, ease of use and low cost; it brings revolutionary opportunities to the analytical community."

Although tested on pesticide molecules, the team's new system could be used to detect any molecule, including drugs, proteins and antibodies. For medicine, where care is moving from hospitals to homes, small, cheap detection systems are vital.

The researchers are now developing kits that can detect different molecules. "We're now making the system useful for real world application," said Prof. Zhang. "We're planning to use the technology to detect multiple molecules at the same time - something called multiplex detection. In this way we could, for example, test the quality of the food we eat every day."

More information: Qingsong Mei et al. Smartphone based visual and quantitative assays on upconversional paper sensor, *Biosensors and Bioelectronics* (2016). DOI: 10.1016/j.bios.2015.08.054

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