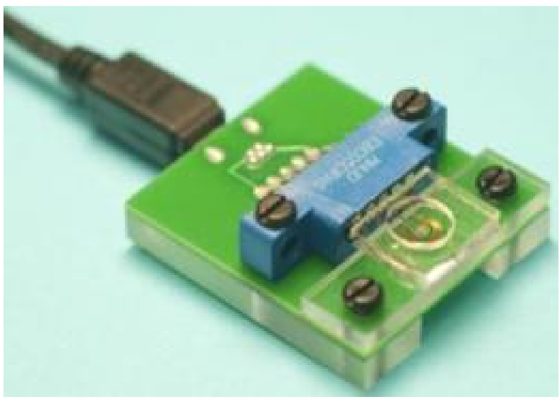
New sensor promises rapid detection of dangerous heavy metal levels in humans

August 1 2011



UC researchers have developed the first lab-on-a-chip sensor to provide fast feedback regarding levels of the heavy metal manganese in humans. The first field test of the sensor will be in 2012. Credit: Dottie Stover, University of Cincinnati

UC researchers have developed the first lab-on-a-chip sensor to provide fast feedback regarding levels of the heavy metal manganese in humans. The sensor is both environmentally and child friendly, and will first be field tested in Marietta, Ohio, where a UC researcher is leading a long-term health study on the potential health effects of heavy metals.

Work by University of Cincinnati researchers to create a sensor that provides fast feedback related to the presence and levels of heavy metals – specifically manganese – in humans is published in the August issue of the prestigious international journal, *Biomedical Microdevices*.

Described in the article is the development of a low-cost, disposable lab-on-a-chip sensor that detects highly electronegative heavy metals more quickly than current technology generally available in health-care settings. It's envisioned that the new UC sensor technology will be used in point-of-care devices that provide needed feedback on heavy-metal levels within about ten minutes.

It's expected that the sensor will have potential for large-scale use in clinical, occupational and research settings, e.g., for nutrition testing in children.

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The new sensor is environmentally friendly in that its working electrode is made of bismuth vs. the more typical mercury, and it's child friendly in that it requires only a droplet or two of blood for testing vs. the typical five-milliliter sample now required.

Explained one of the researchers, UC's Ian Papautsky, "The conventional methods for measuring manganese levels in blood currently requires about five milliliters of whole blood sent to a lab, with results back in 48 hours. For a clinician monitoring health effects by measuring these levels in a patient's blood – where a small level of manganese is normal and necessary for metabolic functions – you want an answer much more quickly about exposure levels, especially in a rural, high-risk area where access to a certified metals lab is limited. Our sensor will only require about two droplets of blood serum and will provide results in about ten minutes. It's portable and usable anywhere."

Papautsky, UC associate professor of electrical and computer engineering, is co-author of the Biomedical Devices-published research, "Lab-on-a-Chip Sensor for Detection of Highly Electronegative Heavy Metals by Anodic Stripping Voltammetry." Other co-authors are Erin Haynes, assistant professor of environmental engineering; William Heineman, distinguished research professor of chemistry; and just-graduated electrical and computer engineering doctoral student Preetha Jothimuthu, just-graduated chemistry doctoral student Robert Wilson, and biomedical engineering undergraduate research co-op student Josi Herren.

First field test of sensor expected in 2012 in Marietta, Ohio

One specific motivation for developing the sensor was an ongoing project by UC's Erin Haynes, who is studying air pollution and the health effects of manganese and lead in Marietta, Ohio. Manganese is emitted in that area because it is home to the only manganese refinery in the United States and Canada. Preliminary results from UC's Mid-Ohio Valley Air Pollution Study (M.A.P.S.) found elevated levels of manganese in Marietta residents when compared to those who live in other cities.

How the sensor works

The new UC sensor uses a technology called anodic stripping voltammetry that incorporates three electrodes: a working electrode, a reference electrode and an auxiliary electrode.

A critical challenge for such sensors is the detection of electronegative metals like manganese. Detection is difficult because hydrolysis, the splitting of a molecule into two parts by the addition of a water molecule, at the auxiliary electrode severely limits a sensor's ability to detect an electronegative metal.

To resolve this challenge, the UC team developed a thin-film bismuth working electrode vs. the conventional mercury or carbon electrode. The favorable performance of the bismuth working electrode combined with its environmentally friendly nature means the new sensor will be especially attractive in settings where a disposable lab-on-a-chip is wanted.

In addition, the UC team also optimized the sensor layout and working-electrode surface to further reduce the effects of hydrolysis and to boost the reliability and sensitivity in detecting heavy metals. The new sensor layout better allowed for its functioning, which consists of taking of a blood serum sample, stripping out the heavy metal and then measuring that heavy metal.

The end result is the first lab-on-a-chip able to consistently pinpoint levels of highly electronegative manganese in humans. The new sensor also exhibits high reliability over multiple days of use, with hours of continuous operation. With further developments, the chip may even be converted into a self-check mechanism, such as with glucose screening for diabetics.

Provided by University of Cincinnati