New analytical tool helps detect cancer

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Scientists have long used ultra-fine glass tubes known as capillaries to analyze the chemical makeup of substances. Called capillary electrophoresis, or CE, the method applies high voltage to the capillaries, and by measuring the rate that the various materials move through the capillaries, researchers are able to identify individual compounds.

A group of researchers at the U.S. Department of Energy's Ames Laboratory have developed a method called dynamic multiple equilibrium gradients, DMEG for short, that dramatically fine-tunes the process, allowing for a significant increase in resolution over previous methods. Potential applications include chemical, biological and biomedical sciences, as well as in environmental monitoring, biological warfare detection, drug discovery, and more.

"This method is hyperselective and we can design it to target specific analytes for separation," said Ryszard Jankowiak, an Ames Lab senior scientist. "Running multiple electric field gradients can focus and move the analytes to the detection window at precisely defined times, creating signature 'fingerprints', which minimizes the probability of false positives."

The advance makes it possible to detect the smallest traces of substances, such as the estrogen-derived conjugates and DNA adducts in human fluid samples that could serve as biomarkers in risk assessment of breast and prostate cancers. In fact, this and other technologies being developed at the Ames Laboratory – biosensors and fluorescence-based imaging – have been used in work with cancer researchers at the University of

Nebraska Medical Center and Johns Hopkins University to identify a specific adduct in the urine of prostate and breast cancer patients, and could lead to even earlier detection or indication of cancer risk.

Unlike traditional capillary electrophoresis, Jankowiak's team, which includes Yuri Markushin and graduate student Abdulilah Dawoud, uses only low voltage, around 2kV or less. Another difference is in the way the voltage is applied. Tiny electrodes are microfabricated along the walls of the hair-like capillaries (or channels), in essence creating a complex grid of electrodes.

"Saw-tooth type waves are applied along the channel outfitted with electrodes," Jankowiak explains. "The electrodes act as capacitors and the applied waveforms generate electric fields. The moving variable electric field gradients induce very efficient focusing and separation of analytes. The analytes move along the capillary and tend to concentrate at the various electric field gradients. By varying the amplitude of the electric field gradients, these concentration points can be fine-tuned, making it easy to separate and identify the specific analytes."

While the ability to design and test for specific analytes with greater accuracy marks a large leap forward in separation technology, DMEG has another, possibly even greater capability. Because the system can be fine-tuned to separate specific substances and concentrate them at particular points as they move through the capillaries, it can be used to create crystals.

"To achieve crystallization, we created multiple moving electric field gradients along the crystallization channel that can trap, concentrate, and move charged molecules (e.g. proteins) of interest," Jankowiak said. "In other words, using the DMEG approach, we can create and electronically control many localized regions of supersaturation which can be used to produce crystals."

One potential application for this new crystal growth method is photosynthetic complexes for use in solar/photovoltaic cells. The major stumbling block in using these materials is that they must be arranged in architectures that promote electron transport and prevent energy wasting recombination. The complexes must also be interfaced with a conducting material in order to harvest the energy. The controlled growth offered by DMEG can help overcome these hurdles.

Another possible application is for desalinization of seawater, using DMEG to extract the salt. Just recently, Jankowiak has been awarded a grant by the Office of Naval Research and NASA to pursue research in this area.

Source: Iowa State University