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Sensor uses DNA to detect presence of lead, a dangerous contaminant

CHAMPAIGN, Ill. — Lead is a common environmental contaminant that can cause a number of health problems, particularly in children. Current techniques for lead detection require sophisticated equipment or complicated sample treatment. Now, researchers at the University of Illinois have developed a simple and inexpensive method that permits real-time, on-site detection of lead ions.

"A unique feature of our lead sensors is that they consist of small pieces of DNA, the same basic building block of our genes," said Yi Lu, a UI professor of chemistry. DNA is a well-known genetic material with different combinations of "code" or sequences that determine individual characteristics such as eye color, hair color and height.

"This represents a new class of simple and environmentally safe sensors and is the first example of a catalytic DNA-based biosensor for metal ions," Lu said. "It combines the high metal ion selectivity of catalytic DNA with the high sensitivity of fluorescence detection."

Because DNA is stable, cost-effective and easily adaptable to optical fiber and chip technology, the catalytic DNA system is an ideal candidate for real-time, remote sensing of lead in applications such as environmental monitoring, clinical toxicology and industrial process monitoring.

To search for the unique sequence of DNA that could distinguish lead from other metal ions, Lu and graduate student Jing Li used a method called in vitro selection. The selection process is capable of sampling a very large pool of DNA sequences (up to 1000 trillion molecules), amplifying the desired sequences by the polymerase chain reaction and introducing mutations to improve performance.

Using in vitro selection, Lu and Li found several DNA sequences that were especially responsive to the presence of lead ions. To enhance the sensitivity of the sensor, the researchers attached a fluorescent tag to a specific

DNA sequence.

While most DNA is double stranded, the catalytic DNA Lu and Li selected has a single strand that can wrap around like a protein. In that single strand, the researchers fashion a specific binding site – a kind of pocket that can only accommodate the metal ion of choice.

"The principles demonstrated in this work can also be used to obtain DNA biosensors for other metal ions that are toxic (such as mercury and cadmium) or beneficial (such as calcium and potassium) to humans," Lu said. "At the same time, we can offer insight into both the sequence and structure of DNA that is responsible for the metal specificity."

Lu and Li described their catalytic DNA sensor in the Oct. 25 issue of the Journal of the American Chemical Society. Funding was provided by the National Institutes of Health. The researchers have applied for a patent.

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