Gold nanoparticles help detect a toxic metal -- mercury

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With gold nanoparticles, DNA and some smart chemistry as their tools, scientists at Northwestern University have developed a simple "litmus test" for mercury that eventually could be used for on-the-spot environmental monitoring of bodies of water, such as rivers, streams, lakes and oceans, to evaluate their safety as food and drinking water sources.

An article detailing the colorimetric screening technology and its success detecting mercury will be published online April 27 by *Angewandte Chemie*, the prestigious European journal of applied chemistry.

Methyl mercury, a neurotoxin that is particularly dangerous to young children and pregnant women, is the form of mercury people ingest when they eat contaminated fish and shellfish. Mercury is released into the air through industrial pollution, falling into bodies of water and polluting the waters in which fish and shellfish live. Bacteria in the aquatic environment then convert water-soluble mercuric ion (Hg2+) into methyl mercury, which accumulates in varying amounts in fish and shellfish.

"It is critical to detect mercury quickly, accurately and at its source," said Chad A. Mirkin, George B. Rathmann Professor of Chemistry, professor of medicine and professor of materials science and engineering, who led the study. "Most existing detection methods require expensive complicated equipment forcing tests to take place in a lab. Our method is simpler, faster and more convenient than conventional methods, and results can be read with the naked eye at the point of use."

The researchers report that they were able to determine by simple visual inspection if solvated mercuric ion was present in each sample tested and, if so, in what amount. As an illustration of the method's selectivity, they also could differentiate mercury from other metals with similar binding mechanisms, such as cadmium and copper.

The method is also highly sensitive, capable of detecting mercuric ions at the 100 nanomolar level. "To the best of my knowledge, we have set a record for the most sensitive colorimetric sensor," said Mirkin. "A glucose meter, for example, operates at a high micromolar scale, with glucose being 100,000 times more concentrated than the mercury we are detecting."

The Northwestern method takes advantage of gold's intense color when the metal is measured on the scale of atoms. Mirkin and his team started with gold nanoparticles, each just 15 nanometers in diameter, held together by complementary strands of DNA. Because they are held together within a certain critical distance, the gold nanoparticles -- and the solution they are in -- are blue. When the solution is heated, the DNA breaks apart, and the gold nanoparticles, no longer in close proximity to each other, are now bright red.

Knowing that mercuric ion binds selectively to the bases of a thymidine-thymidine (T-T) mismatch, the researchers designed each strand of DNA, which is attached to a gold nanoparticle, to have a single thymidine-thymidine (T-T) mismatch. If mercury is present in the solution it binds tightly to the T-T mismatch site.

The key to the technology is that the blue to red color change occurs at 46 degrees Celsius if the solution has no mercury, and it occurs at a higher temperature if mercury is present.

"When mercury binds to the T-T mismatch site it is like adding some superglue -- the gold nanoparticles are now held together even more tightly," said Mirkin. "The mercury creates a stronger bond that requires a higher temperature to break apart the DNA strands."

The temperature it takes to break apart the strands, when the color changes from blue to red, also indicates how much mercury is present -- the higher the temperature, the more mercury or "super glue" that is present.

Their next step, said Mirkin, is to increase the sensitivity of the method as well as expand the scope of environmental targets. Using similar principles, the researchers have started developing a colorimetric screening method for cadmium and lead.

"This is a simple method that we can tailor easily for other metals," said Mirkin.

Source: Northwestern University

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