New sensor provides real-time detection of heavy metals, bacteria, nitrates and phosphates in water

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Water quality monitoring currently occurs mainly at water supply intakes or water treatment plants, rather than along water distribution lines or at the point of use. This is inadequate because negative changes can occur in water quality between the water source and your faucet. It is essential to monitor this key natural resource for various contaminants, such as toxic heavy metal ions, within water distribution and treatment systems.

Accurate and accessible detection technologies are necessary to ensure continuous water quality control and early warning capabilities to avoid public safety catastrophes like the ongoing Flint water crisis in Michigan.

During the AVS's 64th International Symposium & Exhibition, being held Oct. 29-Nov. 3, 2017, in Tampa, Florida, Junhong Chen, distinguished professor of mechanical engineering, materials science and engineering at the University of Wisconsin-Milwaukee, will present his work about inventing a graphene-based sensing platform for real-time, low-cost detection of various water contaminants. The new sensor detects heavy metals, bacteria, nitrates and phosphates.

"Our technology addresses an unmet need for real-time, low-cost monitoring of critical contaminants in drinking water," said Chen. "Water plays an important role in the economic world, but only 3 percent of the available water is potable, and with increasing demand, the need for safe drinking water is rising."

Graphene, a single layer of carbon atoms arranged in a 2-D honeycomb lattice, is a promising nanomaterial thanks to its unique structure and electrical properties.

"Intrinsic graphene is a zero-gap semiconductor that has remarkably high electron mobility (100 times greater than that of silicon), which makes it attractive for sensitive, high-speed chemical and biological sensors due to its high sensitivity to electronic perturbations," he said.

The sensor works by placing graphene-based nanosheets that are semiconducting between an electrode gap. The electrical conductivity of the graphene material changes with the binding of substances, called analytes, to its surface and their chemical constituents are identified and measured.

"The magnitude of the conductivity change can be correlated to the concentration of analyte, and the technology also involves the functionalization of the graphene material surface with specific probes that can target a specific analyte," said Chen.

The sensor is based on a field-effect transistor (FET) device with reduced graphene oxide (rGO) as its sensing channel. "The working principle of the sensor is that the rGO conductivity (usually measured in resistance) changes with the binding of chemicals such as heavy metals to probes anchored on the rGO surface," he said. "So the presence of the chemicals can be determined by measuring the sensor resistance change."

By deploying these real-time sensors to monitor water contaminants in water distribution systems, according to Chen, they could provide early warning of chemical and biological contamination in water, improving water safety and public health benefits.

"The platform technology can also be further engineered to detect various analytes for food and beverages, as well as for biomedical applications," said Chen.

Chen has launched a startup, NanoAffix Science LLC, to commercialize his water-quality sensing technology. With funding from the National Science Foundation and in partnership with several water companies, they've already developed a prototype of a hand-held device for rapid, low-cost detection of lead ions in drinking water. "We're now refining the prototype to make it a commercial product in the near future," said Chen.

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