Researchers Create DNA-Based Sensors for Nano-Tongues and Nano-Noses

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Nano-sized carbon tubes coated with strands of DNA can create tiny sensors with abilities to detect odors and tastes, according to researchers at the University of Pennsylvania and Monell Chemical Sciences Center. Their findings are published in the current issue of the journal *Nano Letters*, a publication of the American Chemical Society.

According to the researchers, arrays of these nanosensors could detect molecules on the order of one part per million, akin to finding a one-second play amid 278 hours of baseball footage or a single person in Times Square on New Years' Eve. In the report, the researchers tested the nanosensors on five different chemical odorants, including methanol and dinitrotoluene, or DNT, a common chemical that is also frequently a component of military-grade explosives. The nanosensors could sniff molecules out of the air or taste them in a liquid, suggesting applications ranging from domestic security to medical detectors.

"What we have here is a hybrid of two molecules that are extremely sensitive to outside signals: single stranded DNA, which serves as the 'detector,' and a carbon nanotube, which functions as 'transmitter,'" said A. T. Charlie Johnson, associate professor in Penn's Department of Physics and Astronomy. "Put the two together and they become an extremely versatile type of sensor, capable of finding tiny amounts of a specific molecule."

Given the size of such sensors each carbon nanotube is about a billionth of a meter wide, Johnson and his colleagues believe arrays of these sensors could serve as passive detection systems in almost any location. The sensor surface is also self-regenerating, with each sensor lasting for more than 50 exposures to the targeted substances, which means they would not need to be replaced frequently.

The specificity of single-stranded DNA is what makes these sensors so capable. These biomolecules can be engineered, in a process called directed evolution, to recognize a wide variety of targets, including small molecules and specific proteins.

Likewise, the nanotubes are ideal for signalling when the DNA has captured a target molecule. Single-walled nanotubes are formed from a single sheet of carbon molecules connected together and then rolled. It is a unique material in which every atom is on both the surface and the interior. Although nanotubes have many applications, they are extremely sensitive to electrostatic variations in their environment, whether the nanotube is in a liquid or in air.

"When the DNA portion of the nanosensor binds to a target molecule, there will be a slight change in the electric charge near the nanotube," Johnson said. "The nanotube will then pick up on that change, turning it into an electric signal that can then be reported."

According to Johnson, an array of 100 sensors with different response characteristics and an appropriate pattern recognition program would be able to identify a weak known odor in the face of a strong and variable background.

"There are few limits as to what we could build these sensors to detect, whether it is a molecule wafting off an explosive device or the protein byproduct of a cancerous growth," Johnson said.

Researchers involved in the project include Cristian Staii, a graduate student in the Department of Physics and Astronomy in Penn's School of Arts and Sciences; Michelle Chen, a graduate student in the Department of Material Science and Engineering in Penn's School of Engineering and Applied Science; and Alan Gelperin of the Monell Chemical Senses Center.

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