By detecting genetic material, fast sensor has potential use as a clinical tool

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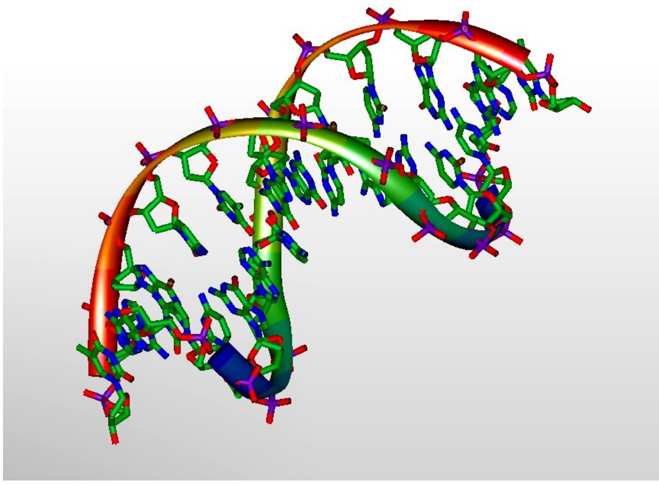

3D-model of DNA. Credit: Michael Ströck/Wikimedia/ GNU Free Documentation License

In less than a second, a small sensor used in brain chemistry research can detect the key molecules that provide the genetic instructions for life, RNA and DNA, a new study from American University shows.

The AU researchers believe the sensor is a useful tool for scientists engaged in clinical research to measure DNA metabolism, and that the sensor could be a quick way for lab clinicians to distinguish 'healthy' from 'sick' samples and determine if a pathogen is fungal, bacterial, or viral, before conducting further analysis.

To explore whether the sensors could detect RNA and DNA, Alexander Zestos, assistant professor of chemistry, teamed up with John Bracht, associate professor of biology, to test a new method for detection of RNA and DNA. Both professors are part of AU's Center for Neuroscience and Behavior, which brings together researchers from a variety of fields to investigate the brain and its role in behavior.

Novel Electrode Measures RNA and DNA

The sensors, also known as carbon fiber microelectrodes, allow researchers like Zestos to conduct precise measurement of chemicals in the brain. Researchers can learn more about the brain's complex circuitry of neural pathways and neurotransmitters, chemicals in the brain that pass messages along a given pathway.

Zestos and Bracht used a typical carbon fiber microelectrode with fast scan cyclic voltammetry, the same kind of sensor used to detect dopamine in the brain. Zestos' work frequently involves using sensors to detect and measure dopamine in the brain, because the neurotransmitter figures in a wide range of activity in the nervous system, from bodily movements to emotional responses.

The researchers modified the sensor with a specialized electrode. They weren't sure that it would work, and were surprised when the electrode, or waveform, detected the oxidative peaks of adenosine and guanosine, two of the building blocks of DNA. The detection time is fast, occurring in less than a second. Research methods were verified using both animal and synthetic RNA and DNA.

A Research Tool and Pre-Diagnostic

In the near term, Bracht and Zestos envision the tool as useful in clinical research. Researchers who use the tool could gain useful information about nucleic acids and measure the relative ratios of adenosine, guanosine and cytidine, another DNA nucleobase. Around the size of a strand of human hair, the sensor is small enough to implant in cells, tissue, or in live organisms. The sensor can detect DNA or RNA in any fluid sample, including liquid droplets, saliva, blood or urine.

The sensor could also be used as a pre-diagnostic. The onset of disease or fungal infection can cause a quick rise in nucleic acids, which the sensor can measure, and possibly predict rapid infections, the researchers said. It can take up to a day or more for results from tests for coronavirus, for example.

"Electrochemical sensors can be used for evaluating samples prior to sequence-based methods," Bracht said. "We can envision several cases where clinically it's useful to quickly measure DNA or RNA in a sample before further sequencing. For example, it might be used when there are a lot of samples to quickly check before doing more extensive testing."

One current limitation is the sensor will need to detect more than just the strands of DNA and RNA. To detect a specific virus or for genetic testing, the sensor will need to detect the gene sequence of a virus. A next step in the research will be to modify the sensor further to see if the sensor can detect a virus. The sensor potentially has a variety of applications for which further research will be needed, including within forensic science and other fields where sensors play a prominent role.

"We have also thought about whether we can measure DNA metabolism inside living brains and cells," Bracht said. "We could possibly use one electrode to measure neurotransmitters like dopamine and also measure DNA and RNA and their building blocks in real-time in a brain."

The new research is published in the chemistry journal *ACS Omega*.

More information: Thomas M. Asrat et al, Direct Detection of DNA and RNA on Carbon Fiber Microelectrodes Using Fast-Scan Cyclic Voltammetry, *ACS Omega* (2021). DOI: 10.1021/acsomega.0c04845