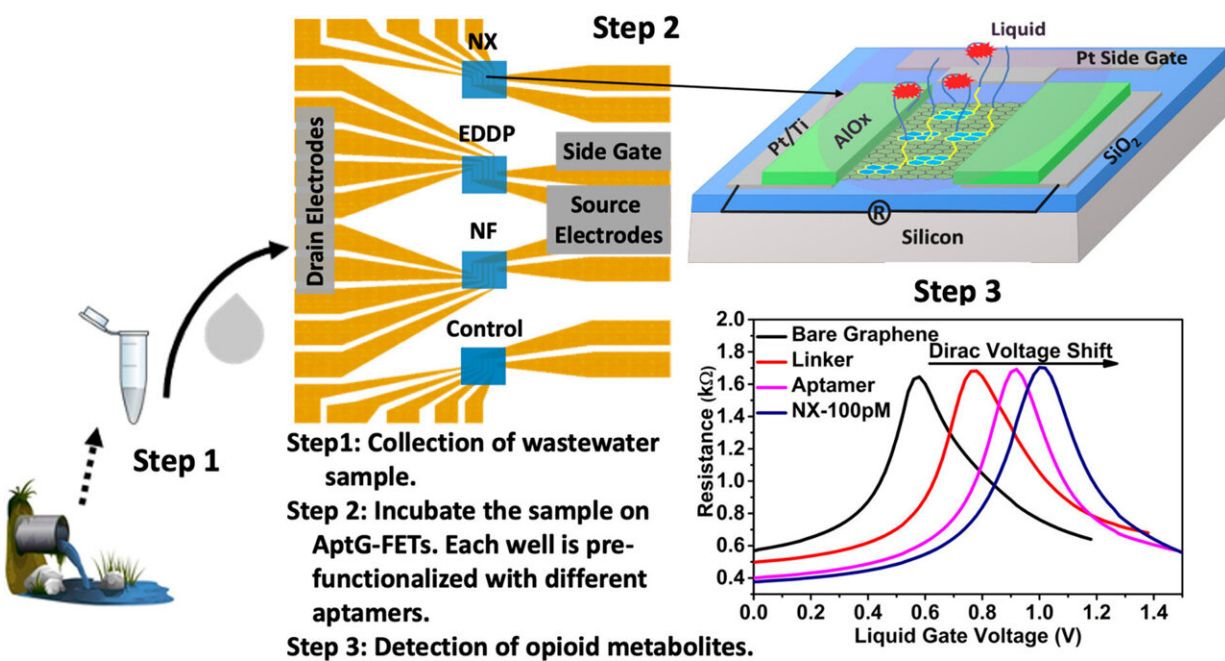


Graphene sensor rapidly detects opioid metabolites in wastewater

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Developed by researchers at Boston College, Giner Labs and Boston University, the graphene electronic multiplexed sensor (GEMS) platform enables the simultaneous sensing of four different target opioid-derived molecules in wastewater samples. Credit: *ACS Nano* (2022). DOI: 10.1021/acsnano.1c07094

The unique properties of the atom-thick sheet of carbon, known as graphene, enabled a new penny-sized, multiplexed bio-sensor that's the first to detect opioid byproducts in wastewater, a team of researchers from Boston College, Boston University, and Giner Labs report in the

latest online edition of the journal *ACS Nano*.

The [novel device](#) is the first to use [graphene](#)-based [field effect transistors](#) to detect four different synthetic and natural opioids at once, while shielding them from wastewater's harsh elements. When a specific opioid metabolite attaches to a molecular probe on the graphene, it changes the [electrical charge](#) on the graphene. These signals are easily read electronically for each probe attached to the device.

"This new sensor we've developed is able to rapidly, cheaply, and easily measure opioids in wastewater," said Boston College Professor of Physics Kenneth Burch, a lead author of the report. "Its sensitivity and portability would allow for wastewater-based epidemiology at the local scale—as specific as block-by-block or dorm-by-dorm—while ensuring privacy."

The device responds to a primary challenge of the opioid epidemic: determining the amount and kind of drugs being used in a community. Privacy concerns and limited resources are barriers to testing large populations. An alternative approach is wastewater-based epidemiology, similar to testing wastewater to measure community levels of coronavirus infection during the pandemic.

"Wastewater testing is an emerging strategy that can defeat limitations and stigma associated with individual drug testing, and it provides a more objective measure of drug use at neighborhood level," said Giner Labs Vice President for Advanced Materials Avni Argun, a co-leader of the project. "While wastewater testing has been widely conducted in Europe, only a few studies exist in the US. Rapid and portable nature of the team's device would allow wide scale population testing at low cost and high geographical resolution."

The work of Argun's team at Giner Labs, in Newton, Mass., is funded by

the NIH's National Institute on Drug Abuse, which is working with researchers to develop smart city tools that would assist public health surveillance programs addressing drug use and abuse. Additional funding for the project came from the National Science Foundation, National Institutes of Health, and the Office of Naval Research.

The team's prototype could provide a cheaper and faster tool for use by public health officials trying to determine the level of opioid usage and the impact of community-wide treatment interventions.

While graphene has been used before for sensing biological samples, the team's work is the first demonstration that the material could be used with wastewater, Burch said.

In addition, it is the first demonstration of using graphene-based field effect transistors, an electronic device to read the amount of charge, to detect multiple targets at the same time, according to the report.

The breakthrough was enabled by the design and implementation of the graphene electronic multiplexed sensor (GEMS) platform, Burch said. The platform enables the sensing of four different target molecules at once, while shielding them from harsh elements in waste water, samples of which were provided by the Mass. Alternative Septic System Test Center (MASSTC) on Cape Cod.

The team fitted the graphene probes with "aptamers", strands of DNA designed to only attach to a specific molecule—in this case, metabolites of various opioids in waste water. When the aptamer attaches to the drug it folds, bringing more charge to graphene. The amount of charge on the graphene is monitored to detect the presence of a specific opioid metabolite, Burch said.

"These aptamers were attached to our graphene devices and when

trapping the drug the induced charge on the graphene was read electronically," Burch said. "Our fabrication process and design resulted in a lower limit of detection an order of magnitude better than previous reports by other methods."

Prior sampling tools faced the limitations because they required the shipping of samples and testing in a laboratory setting. Those requirements impose costs that limit wide adoption and use in communities without sufficient resources. By overcoming those limits, the graphene device can provide nearly real-time monitoring in multiple locations, which could also help distribute resources such as first responders or specific intervention strategies, Burch said.

"This is the first such sensor that can achieve it with such a simple and easy-to-use setup—a single GEMS platform is the size of a penny," Burch added.

The success of GEMS resulted from a long-term collaboration led by Burch, bringing together the DNA expertise of Boston College Associate Professor of Biology Tim van Opijnen, graphene cultivation by Boston University chemist Xi Ling, and biosensor assay development expertise of Argun and scientists from Giner Labs.

Additional researchers on the project included Boston College graduate student Michael Geiwitz, research scientist Narendra Kumar, undergraduate Matthew Catalan, and post-doctoral researcher Juan C. Ortiz-Marquez; Giner Labs' Muhit Rana, Niazul Islam Khan, Andrew Weber, and Badawi Dweik; and BU graduate student Hikari Kitadai.

Burch said the team was surprised at how well the device withstood the harsh wastewater environment. He said his lab is working with Giner Labs under NIDA small business innovation research (SBIR) funding to develop the devices for eventual commercial use.

"We are also working to see what else the platform can be used for, such as rapid at-home testing of viral infections and/or the presence of pathogens in wastewater," Burch said.

More information: Narendra Kumar et al, Rapid, Multianalyte Detection of Opioid Metabolites in Wastewater, *ACS Nano* (2022). [DOI: 10.1021/acsnano.1c07094](https://doi.org/10.1021/acsnano.1c07094)

Provided by Boston College

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