New cost-effective method can detect low concentrations of pharmaceutical waste and contaminants in water

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Pharmaceutical waste and contaminants present a growing global concern, particularly in the context of drinking water and food safety.

Addressing this critical issue, a new study by researchers at Bar-Ilan University's Department of Chemistry and Institute of Nanotechnology and Advanced Materials has resulted in the development of a highly sensitive plasmonic-based detector, specifically targeting the detection of harmful piperidine residue in water.

The team's work is published in the journal *Environmental Science: Nano*.

Piperidine, a small potent molecule that serves as a building block in the pharmaceutical and food additive industries, poses significant health risks to both humans and animals due to its toxic nature. Detecting even miniscule amounts of piperidine is essential for ensuring drinking water and food safety. The plasmonic substrate developed at Bar-Ilan University, comprising triangular cavities milled in a silver thin film and protected by a 5-nanometer layer of silicon dioxide, offers unparalleled sensitivity to piperidine, detecting low concentrations in water.

Mohamed Hamode, a Ph.D. student at Bar-Ilan's Department of Chemistry, in collaboration with Dr. Elad Segal, developed the dime-sized device using a focused ion microscope to drill nanometer-sized holes on a metal surface. By programming the beam with a custom-built computer program, Hamode creates holes of various shapes.

These holes, smaller than the wavelength of visible light, enhance the electrical field on the surface, leading to concentrated light in very small areas. This amplification enables optical phenomena to be significantly increased, allowing for the identification of a low concentration of molecules that were previously undetectable with optical probes.

Due to its confined and enhanced electromagnetic field, the plasmonic substrate offers an efficient alternative to other substrates currently used in Surface Enhanced Raman Spectroscopy (SERS), opening avenues for

the use of cost-effective and portable Raman devices that enable quicker and more affordable analysis.

"This study represents a significant advancement in the field of environmental monitoring," said senior researcher Prof. Adi Salomon, of Bar-Ilan's Department of Chemistry and Institute of Nanotechnology and Advanced Materials. "By leveraging nano-patterned metallic surfaces, we've demonstrated the detection of low concentrations of piperidine in water using affordable optics, offering a promising solution for environmental analytical setups."

The findings of the study underscore the potential of plasmonic-based detectors in revolutionizing environmental monitoring, particularly in the detection of pharmaceutical waste and contaminants. Next week, Mohamed Hamode will present the innovation at an international conference on microscopy taking place in Italy.

More information: Mohamed Riad Hamode et al, Plasmonic Based Raman sensor for Ultra-sensitive detection of Pharmaceutical waste, *Environmental Science: Nano* (2024). DOI: 10.1039/D3EN00821E

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