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Viehrig, Marlitt; Rindzevicius, Tomas; Zor, Kinga; Schmidt, Michael Stenbæk; Boisen, Anja

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Surface enhanced Raman spectroscopy (SERS) sensing in aqueous sample enabled by UV/ozone treatment

Marlitt Viehrig1, Tomas Rindzevičius1, Kinga Zör1, Michael S. Schmidt1, Anja Boisen1

1The Danish National Research Foundation and Villum Foundation’s Center for Intelligent Drug Delivery and Sensing Using Microcontainers and Nanomechanics (IDUN), Department of Micro- and Nanotechnology, Technical University of Denmark, Kgs. Lyngby, Denmark.

We present the development of a detection strategy based on surface-enhanced Raman spectroscopy (SERS) sensing in water. The SERS substrates, fabricated from free-standing, gold-capped silicon nanopillars are commonly used for the detection of analytes dissolved in organic solvents and dried on the sensor surface. We developed a method where detection can be performed directly in aqueous samples using a model drug acetoaminophene (Paracetamol).

SERS sensing in Water

Pharmaceuticals have become integral parts of our daily life. However, this widespread availability poses a potential risk of leakage into our environment leading to possible disturbances in various eco systems. Even though low concentrations of single drugs are not necessarily harmful, cross-reactions with other drugs and accumulation can be dangerous if not carefully monitored.

SERS Substrate - Gold Capped Nanopillars

SERS is a powerful analysis technique capable of detecting molecular fingerprints of analytes with high sensitivity and fast response time. [2]

Classical dry droplet SERS sensing using gold-capped Si nanopillars. [3] Dry droplet measurements are highly influenced by the chosen sample matrix.

Complex matrices can lead to sensor fouling. Organic solvents are preferred, due to the hydrophobic nature of the nanopillar surface.

Dry droplet SERS-based detection of 350 µM paracetamol in various aqueous matrices.

Surface Treatment

UV/ozone exposure is commonly utilized as surface treatment and cleaning procedure in a variety of microfabrication processes. It renders the surface of gold-capped nanopillars from hydrophobic to hydrophilic without any morphological alterations.

Direct Paracetamol detection in MQ was possible over a linear range of 5 – 100 µM.

350 µM Paracetamol spiked in PBS, tap water and unfiltered river water shows that UV/Ozone pre-treatment allows detection in a realistic environment.

UV/ Ozone Treatment

UV/ozone surface treatment resulted in a lowered background signal, more defined peak shape and homogenous wettability in aqueous samples in comparison to untreated and preleaned samples. Optimal signals were obtained after 30 min of treatment and samples were stable for 3 hrs in an ambient environment.

Liquid Measurements

UV/ozone treatment enabled the development of a novel liquid measurement technique for nanopillar SERS based sensing.

UV/Ozone Exposure Time [min]

Time in Ambient Environment [min]

Concentration [µM]

References

