亮点报道：基于咖啡环效应的多特征 SERS 分析技术用于水中痕量纳米塑料的定量检测

DOI: 10.12086/oee.2025.251009.h02

当前，基于表面增强拉曼光谱术 (SERS) 的纳米塑料检测面临的最大问题是如何对痕量纳米塑料进行精准定量分析。纳米塑料在真实水环境中的浓度较低，通常为 μg/L 量级，一般 SERS 基底的检测灵敏度无法满足实际的检测需求。

山东师范大学物理与电子科学学院的研究团队提出了一种基于咖啡环效应的全新 SERS 检测策略：该团队首先制备了一种具有较高灵敏度的超疏水 CuO/Ag SERS 基底用于产生咖啡环效应，并且在疏水修饰过程中采用红外辐射法，避免了利用氟硅烷、硬脂酸等有机物修饰对检测可能带来的干扰。研究团队发现，基底表面咖啡环的内径与液滴中纳米塑料的浓度呈负相关关系。此外，由于咖啡环的富集作用，即使在纳米塑料浓度较低时，也可以在较小的检测区域内进行拉曼 mapping 扫描，并收集到较多的有效拉曼光谱信息。

该工作有效将 SERS 技术与浸润性修饰技术进行了结合，既兼顾了 SERS 光谱的高灵敏性和指纹特性，同时又克服了超低浓度时拉曼信号强度无法准确反应分析物浓度变化的缺陷，因此具有很强的实用性，对于未来开展精确的纳米塑料 SERS 测量提供了一种全新的思路。

Opto-Electronic Advances, 2025, **8**(6): 240260.
https://www.oejournal.org/article/doi/10.29026/oea.2025.240260

Highlights: A novel strategy for detecting trace-level nanoplastics in aquatic environments: multi-feature machine learning-enhanced SERS quantification leveraging the coffee ring effect

DOI: 10.12086/oee.2025.251009.h02

Critical limitations persist in translating surface-enhanced Raman spectroscopy (SERS) to environmental monitoring applications, particularly regarding quantitative analysis of trace-level nanoplastics. Field samples typically contain nanoplastic concentrations in the μg/L range, where conventional SERS substrates demonstrate insufficient sensitivity for practical monitoring requirements.

The research team from the School of Physics and Electronic Science at Shandong Normal University has proposed an innovative SERS detection strategy leveraging the coffee ring effect. Experimentally, the team first developed a superhydrophobic CuO/Ag SERS substrate with enhanced sensitivity to generate the coffee ring effect. Crucially, they employed an infrared radiation technique during the hydrophobic modification process, effectively eliminating potential interference caused by traditional organic modifiers such as fluorosilanes and stearic acid. This methodological advancement ensures cleaner spectral signatures while maintaining substrate functionality for precise nanoplastic detection.

This work innovatively combines SERS technology with surface wettability engineering, simultaneously preserving the technique's inherent advantages of high sensitivity and molecular fingerprint specificity while overcoming the critical limitation of unreliable Raman intensity-concentration correlations at ultralow analyte levels. This methodological breakthrough holds significant implications for advancing risk assessment protocols and developing mitigation strategies against nanoplastic contamination in agricultural ecosystems.

Opto-Electronic Advances, 2025, **8**(6): 240260.
https://www.oejournal.org/article/doi/10.29026/oea.2025.240260