Polydopamine functional interfaces for nanoplastics capture and Raman-based detection

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Detecting plastic particles in the micro- and nanoscale range remains challenging for most analytical techniques, despite the growing need for reliable monitoring in environmental samples. Surface-enhanced Raman spectroscopy (SERS) offers very high sensitivity and has emerged as a promising tool for micro- and nanoplastics identification via their vibrational fingerprints. [1] Recent SERS-based approaches, however, often rely on demanding sample pretreatment or on drying aliquots onto SERS-active substrates, steps that can introduce artifacts such as coffee-ring effects and lead to uneven analyte distribution. In addition, many reported platforms require time-consuming fabrication and complex synthetic procedures.[2]

Here we exploit the strong adhesive properties of polydopamine (PDA) as a simple interface for nanoplastics capture and pre-concentration, coupled with Raman spectroscopy and SERS for their detection. Using polystyrene nanoparticles (PS-NPs) as a model system, we investigate how pH influences the grafting efficiency of PDA-coated surfaces and compare the behavior of PS-NPs bearing different terminal functional groups. We showed how, once efficiently immobilized on PDA, larger particles can be readily detected by conventional Raman spectroscopy in aqueous suspensions at ppm concentrations.

To extend detection toward smaller particle sizes, gold nanostars were anchored onto the PDA layer, leveraging its chemical versatility to create a SERS-active interface. This hybrid platform enables the identification of PS-NPs down to 15 nm at ppm levels. Finally, preliminary results toward quantitative detection in water samples are presented by transferring PDA's adhesive functionality onto a three-dimensional cellulose-filter scaffold, providing an encouraging route to scalable preconcentration and size-independent SERS detection of nanoplastics pollutants.

References

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