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Synthesizing Fluorescent Polystyrene Nanoparticles: One Step Towards Testable and Reference-Grade Fluorescent Nanoplastics

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Nanoplastics, defined as plastic particles less than 1 µm in diameter, are emerging contaminants with far-reaching consequences due to their small size and high surface-to-volume ratio. They have the potential to interact with the environment and organisms in ways that microplastics cannot. As fluorescence-based methods are commonly employed in exposure studies, fluorescent labelling of nanoplastics enables the investigation of the fate and transport of nanoplastics in environmental samples and organisms [1]. However, reference-grade fluorescent nanoplastics do not exist based on the definitions of the National Institute of Standards and Technology and ISO Guide 30 [2]. Alternatively, commercially available fluorescent nanoplastics contain surfactants, additives, and specific fluorescent dyes, which are prone to underestimation of fluorescence due to quenching by photosynthetic pigments. Low yields, limited standardization of particle diameter, and potential contamination limit the effectiveness of top-down approaches for fluorescent nanoplastics generation [3].

Therefore, our aim is to outline experimental procedures that can serve as a first step towards generating reference-grade fluorescent nanoplastics. In this study, we developed protocols for synthesizing fluorescent polystyrene nanoparticles. Anionic and cationic fluorescent polystyrene nanoparticles with diameters of 15-70 nm were generated with Celestine Blue. The incorporation of the fluorescent dye was confirmed by fluorescence spectroscopy and laser-scanning confocal microscopy. In addition to Attenuated total reflectance Fourier-transform infrared spectroscopy (ATR-FTIR) and Raman spectroscopy, characterization of fluorescent polystyrene nanoparticles was performed using surface-enhanced Raman spectroscopy (SERS) with silver nanoparticles. Raman spectra of individual and/or aggregates of fluorescent polystyrene nanoplastics were obtained. Overall, the synthesized fluorescent polystyrene nanoparticles represent a promising step forward towards producing reference-grade fluorescent nanoplastics. We also show that SERS remains a promising platform for analyzing fluorescent nanoplastics, with implications for detecting and examining the impacts of trace nanoplastics in environmental and biological samples.

References

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