Chasing Nanoplastic by optical means

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Abstract

The nanoplastics (NPS) harm to biological systems[1] is a growing threat[2], increasing with the NPs fragmentation (size$\leq$ 1 μm) through photochemical and mechanical processes.[3] Detection and characterization of NPS, in particular with optical means, is then a necessity, made challenging by the NPs by the lacking of the refractive index (RI) connection with the particle size and mophology. In this framework, nanometric polystyrene beads (PSbs) are a perfect benchmark system for new detection and characterization methods. However, the current tools to characterize PSbs, either destructive but morphology-aware, or non-destructive but morphology-blind,[4–6] cannot robustly resolve the morphological complexity of PSbs in realistic, heterogeneous samples.

To bridge this gap, we link the optical scattering spectra to the morphological properties of PSbs by using monodispersed PSbs deposited on a sapphire (Al_2O_3) substrate via spin coating. The optical components (total transmission and reflection, diffuse transmission and reflection) are fitted with a new optical model based on the Mie theory. The model, accounting for the surface density and PSbs size distribution, provides and links the PSbs complex RI to the specific sample morphology, validated through atomic force microscopy (AFM). The model addresses the limitations in the existing inversion techniques by incorporating scattering and morphological effects, in particular in the 180-400 nm range. Furthermore, we show a connection among the aggregation morphologies and optical features for different PSbs sizes (r=50-250nm). Using a custom-developed automated AFM image analysis workflow, we quantified the number of PSbs, their size dispersion as well as their aggregation number. This allows to assign the specific features in the diffuse optical spectra to size or aggregation effects, and we validate the link by providing scattering simulations based on the discrete dipole approximation,[7] incorporating both morphology and substrate interference effects.

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