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Nanoplastics Interactions with Pulmonary Surfactant Models: Insights from Experiments and Atomistic Simulations

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The growing presence of nanoplastics in the environment requires urgent investigation since, unlike microplastics, their behavior and impacts remain poorly understood. We combined experimental measurements with atomistic molecular dynamics simulations to elucidate how polystyrene (PS) nanoparticles interact with lung surfactant films. Using realistic, multicomponent models of surfactant monolayers and bilayers alongside Langmuir trough experiments, Brewster angle microscopy, and generalized polarization fluorescence on porcine-derived surfactant, we examined the effects of PS of varying chain lengths. Our results reveal that PS nanoparticles readily adsorb into the hydrophobic regions of both monolayers and bilayers, where shorter chains tend to unfold while longer chains remain coiled. This incorporation increases lipid ordering, slightly expands the lipid area, and promotes lateral lipid reorganization, including cholesterol exclusion. Moreover, our results indicate that PS can be transferred from the lung surfactant to other lung structures. These findings suggest that PS nanoplastics can compromise lung surfactant structure and function, potentially impairing respiratory mechanics and posing risks to human health.