Controlling assembly at the air-water interface through protein-nanoparticle pairing: the effects of protein structure, flexibility and NP interaction.

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Controlling the assembly of nanostructured layers at fluid interfaces is key to nanoscience given their role in functional materials and biological systems. How nanoparticles (NP) adsorb, pack and organise at the interface affects the performance, stability, mechanical response and functionality of the interfacial layer. However, achieving rational control over these processes remains a challenge. A common approach to tuning NP interfacial behaviour is to use surface-active ligands that modify particle wettability and interparticle interactions [1]. Thanks to their amphiphilicity, structural heterogeneity and conformational adaptability, proteins can form complex, dynamic interfacial films, making them particularly attractive yet under-explored interfacial modifiers [2].
We systematically investigated the interaction between model negatively charged silica NPs and three model proteins that, while sharing a negative state at neutral pH, differ in structure and flexibility: bovine serum albumin, β-lactoglobulin and β-casein. Using a combination of bulk-sensitive (circular dichroism, fluorescence spectroscopy, dynamic light scattering) and interface-specific (dynamic surface tension, grazing incidence small-angle X-ray scattering and compression isotherms at the air–water interface) techniques, we established a direct link between protein–NP interactions in bulk solution and the structure, packing, and mechanics of the resulting interfacial layers and demonstrated that NP interfacial assembly can be rationally controlled through protein-NP pairing.
Beyond providing fundamental insight into hybrid interfacial systems, these findings are directly relevant to the design of protein-NP building blocks for applications where controlling interfacial assembly at the molecular level is the key to unlocking system performance.

Keywords:
Fluid interfaces, protein-NP interaction, protein structure, protein stability, mixed protein-NP films, adsorption

References:

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