Bridging Scales and Methods: Novel Characterization of Crystallising and Non-crystallising Emulsifiers at Oil-Water Interfaces

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A fundamental challenge in emulsion science has been disentangling interfacial phenomena from bulk behaviour. We present a novel approach using isolated oil-water interfaces to directly study both crystallising and non-crystallising emulsifiers at the interface.

Our isolated interface methodology enables characterization of interfacial crystallisation separate from bulk effects. Using Small and Wide-Angle X-ray Scattering directly on oil-water interfaces, we reveal how dairy proteins reduce mono- and diglyceride crystallization temperature while preserving crystal structure - insights previously masked by bulk crystallization. Drop shape analysis captures real-time protein displacement during interfacial crystal formation [1].

For non-crystallising emulsifiers, we introduce oil-infused polyelectrolyte multilayers as isolated interface mimics, enabling direct chemical identification of protein-surfactant interactions via ATR-FTIR spectroscopy. This approach reveals that β-lactoglobulin adsorbs irreversibly to oil-water interfaces, with Tween 60 co-adsorbing rather than displacing the protein - challenging conventional displacement models.

These isolated oil-water methodologies provide new insights into emulsifier behaviour by separating true interfacial phenomena from bulk contributions. Our approaches enable more informed emulsion design and advance understanding of both crystallising and non-crystallising emulsifier systems, with applications in food, pharmaceutical, and cosmetic formulations [2].

Literature:

1. MacWilliams, S.V., et al., *Isolating the interface of an emulsion using X-ray scattering and tensiometry to understand protein-modulated alkylglyceride crystallisation.* Journal of Colloid and Interface Science, 2023. **630**: p. 202-214.
2. Webber, J.L., et al., *ATR FTIR spectroscopy of protein and surfactant adsorption to the oil-water interface.* Colloids and Surfaces A: Physicochemical and Engineering Aspects, 2023. **677**: p. 132330.