Influence of surfactant architecture on interfacial energies and work of adhesion in oil detachment

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The efficient detachment of oil from solid substrates is governed by the combined behavior of the three relevant interfaces: water-oil (WO), oil-substrate (OS), and water-substrate (WS) [1]. While recent research has mainly focused on the water-oil interface and its interfacial tension, a comprehensive understanding requires analyzing the interplay of all three interfaces and the resulting work of adhesion, which integrates their respective interfacial energies [2]. The aim of this work is therefore to investigate how the molecular architecture of surfactants modifies the interfacial energies at all three interfaces and how an optimal balance among them can minimize the energetic barrier for oil detachment.
To experimentally study the relationship between surfactant structure and the resulting work of adhesion, a suitable model surface is required. Therefore, a cellulose-imitating surface was developed. Unlike cellulose fibers, this surface provides a simplified, reproducible topography that enables reliable contact angle measurements while replicating the surface free energy and polar-dispersive contribution ratio of native cellulose. Furthermore, a microfluidic model was created to analyze oil detachment under well-defined, controlled conditions. The precisely adjustable flow dynamics allow the work of adhesion to be calculated and enable monitoring of the deformation behavior of oil droplets at varying flow velocities.
This approach provides a robust platform for gaining deeper insights into how the surfactant molecular structure, aggregation behavior, and physicochemical properties of surfactants collectively govern interfacial processes and ultimately influence application performance.

Keywords:
interfacial energies, work of adhesion, surfactant architecture, oil detachment

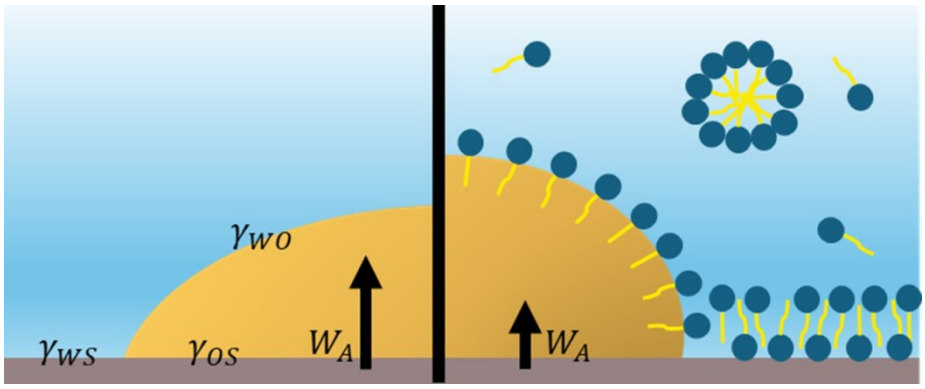

Figure 1: Change in droplet shape upon addition of surfactants. The interfacial tensions at the water-oil (WO), oil-substrate (OS), and water-substrate (WS) interfaces determine the contact angle and the work of adhesion (WA). Introducing surfactants alters the interfacial tensions and the WA.

References:

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