Doing the dishes with neutrons: milli-flow SANS-DLS of fat removal

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Understanding the mechanisms and kinetics of the removal of fat components such as triacyl glycerides (TAGs) from surfaces is of importance for the design of novel surfactant-based formulations for enhanced performance. Pairing of the physico-chemical properties of surfactants, [1] fat components, [2] and substrates [3] dictates the macro-scale removal/cleaning mechanism and kinetics, [4] with simulations reporting a number of nano-to-molecular scale pathways for these mechanisms. [5] Here, we present a coupled in-line milli-fluidic SANS- microfluidic DLS approach to probe both substrate (glass and PDMS) supported TAG structures and nano-to-microscale dynamic solution structures under constant surfactant solution flow (Fig. 1a), using a model 'dish-washing' interesterified TAG and surfactant solution of 3:1 mol sodium dodecylsulfate and N,N-dimethyldodecylamine-N-oxide.

From scattering profiles and correlograms, we obtain a plethora of structural and interaction insights into the range of resulting solution structures and an estimation of surfactant partitioning between them (non-interacting micelles, loaded micelles, nano- and micro-scale emulsions), and we thus infer a 'monomer economy', %ME, for both dissolution-emulsification and delamination TAG removal mechanisms. Furthermore, the time-dependence of I_0 acts as a probe for the ingression kinetics of the surfactant solution into the TAG by the increase in the volume fraction of fractal interfaces, and we discover a concentration-time superposition for the dissolution-emulsification mechanism. Overall, we show two limiting cases for TAG removal (concentration-limited and mechanism-limited, Fig. 1b), and thus the balance between removal kinetics and molecule economy, these being valuable insights for the bottom-up development of the next generation of surfactant formulations, either through their synthesis or by leveraging synergistic interactions.

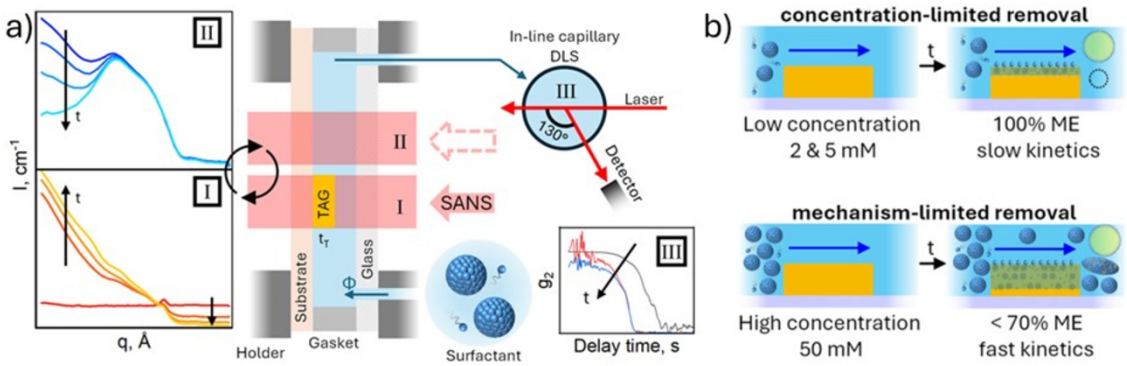

Figure 1: a) SANS-DLS experimental setup. SANS measurements alternate between regions I and II and DLS measurements taken at III. b) The two removal-limiting conditions, with corresponding solutions structures formed, surfactant ingression, and balance between monomer efficiency and kinetics.

References:

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