Foam films stabilized by microgel particles : Insights from the dynamic thin film balance

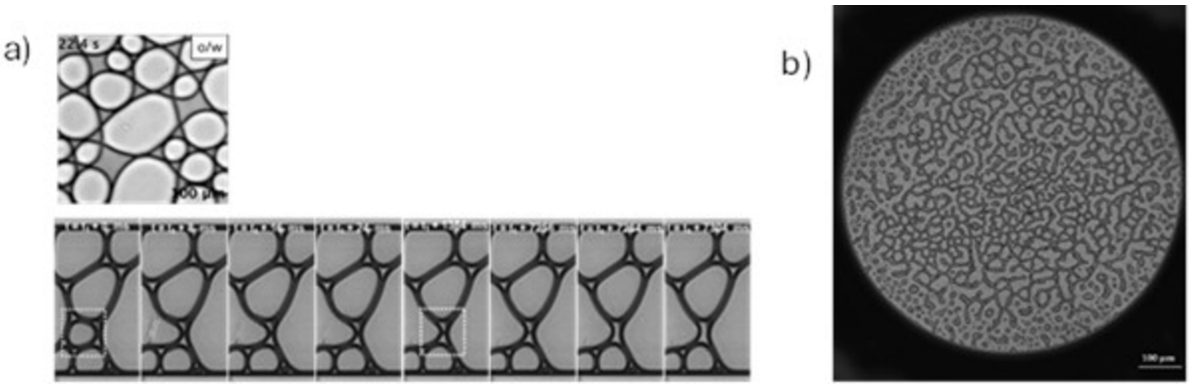
Manaswini Gowtham V [2], Xuefeng Shen [1], ManolisChatzigiannakis [2], SiddharthDeshpande [1], Jasper van der Gucht [1]

[1] Physical Chemistry and Soft Matter, Wageningen University, The Netherlands
[2] Processing and Performance Group, Mechanical Engineering Department and Institute of Complex Molecular Systems, Eindhoven University of Technology, The Netherlands

m.gowtham.vidyashankar@tue.nl

Foams are multiphase materials that are prevalent around us , spanning diverse industrial, food and personal care applications, and also driving fundamental scientific questions. The thin films of liquid (TLFs) present between foam bubbles in proximity govern the lifetime beyond which bubble coalescence occurs. The dynamic thin film balance (TFB) is a versatile technique that uses precise pressure control to emulate thin liquid foam films created in a (bikewheel) microfluidic chip [1]. In this study we focus on Pickering foams stabilized by soft colloidal particles – PNIPAM core-shell type microgel particles that can deform at a fluid-fluid interface. Microfluidic experiments resulted in the generation of emulsion droplets and foam bubbles with bridged interfaces (Fig. a), specifically to control and closely observe bridging and to induce controlled de-bridging. Upon drainage of the simulated interstitial film , a highly heterogenous film with an arrangement of dark and bright regions is formed. The film lifetimes have a distribution, skewed towards high lifetimes at higher pressures (≥ 20 mins) (Fig. b). The dark and bright regions correspond to uneven bilayer-like and monolayer arrangement of particles within the film, with the monolayer regions resulting in "bridged interfaces". We show that the distribution of mono/bilayer-like regions within the film in fact depends on the pressure under which drainage occurs and that film stability correlates with the amount of monolayer regions. De-bridging induced by pressure reversal/reduction did not result in film rupture and the TLF remained stable despite multiple cycles of applied ±ΔP, to drain and thicken the film. Differences are observed in the rate of film expansion and retraction, that can be attributed to the presence of bridging/monolayer regions, that becomes a controlling step in liquid inflow towards the center of the film during film retraction. This hypothesis is evidenced by thickness differences estimated between these regions and by probing de-bridging behavior by reversal of the direction of applied pressure. We examine foam films stabilized by microgel particles at the thin film scale, at pressures relevant to realistic hydrodynamic conditions of drainage, and show that increasing the pressure that drives drainage beyond the typically employed range [2,3], results in ab initio defined interfacial structures, which in turn influence film stability. The pressure-dependent film structures affect significantly the subsequent film thickening.

Keywords:
thin liquid films, foams, microgel particles, bridging



(a) Bridged emulsion droplets & foam bubbles (b) Thin liquid film at the end of drainage (stabilized by core-shell microgel particles)

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