Atomic force microscopy of undried Pickering emulsions at the nm and µm scale

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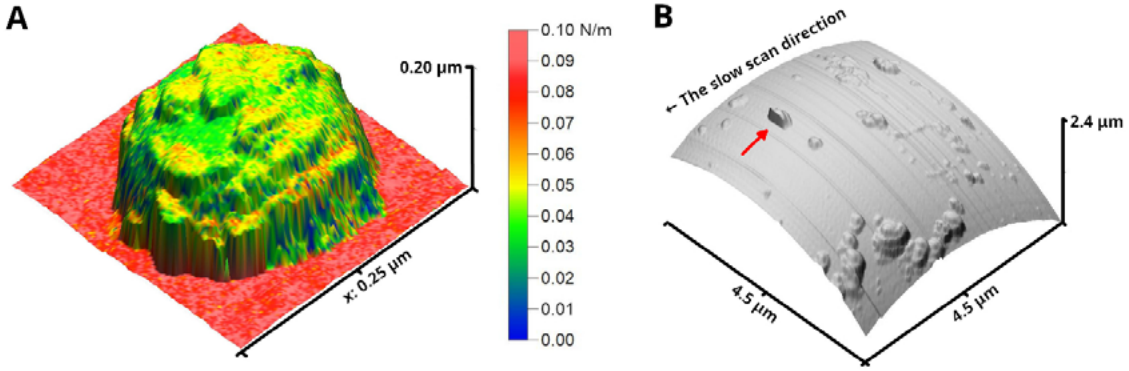
Atomic Force Microscopy (AFM) can measure delicate interfaces and their mechanical properties in nanoscale detail. We recently showed that real-world emulsions with interfacial nanoparticles ("Pickering emulsions") can be analyzed, moved, and merged under water with AFM (Fig. 1A). [1] Lignin (LNP) and silica nanoparticles (SiNP) were used to compare the behavior of soft biomatter to that of rigid inorganic particles. Interfacial LNPs were smaller than the LNPs before emulsification (ø ~100 nm), and they may have been partially smeared in the interface, while rigid SiNPs remained the same size and shape as the originals. Building on this, we now expand the results to a larger droplet size class, from 1 µm up to 10 µm wide, that have been prepared with a low-energy microfluidic method. [2] Surprisingly, LNPs were even more varied in size and how they behaved in the interface than the LNPs in the small droplets prepared by ultrasonication: the larger-droplet LNPs had aggregates, and some LNPs detached during the imaging (Fig. 1B). Clearly, there is more to be found on the interfacial behavior of soft bioparticles, which often are presumed to be intact, well-attached, or separate from each other in the interface. Besides presenting results, I will discuss general opportunities and pitfalls in AFM analysis of Pickering emulsions. The opportunities include high-detail topographical data perfectly aligned with mechanical data, and the option to mechanically manipulate the sample droplets and interfacial nanoparticles during the measurement. The pitfalls include unintentional alterations in the sample caused by the measurement. These problems are more prominent with droplets taller than the AFM tip, droplets with low coverage by the interfacial particles, and occasionally with micron-scaled droplets for a reason that remains to be resolved.

Keywords:
Atomic force microscopy, emulsion, Pickering emulsion, interfacial particles, lignin



AFM micrographs of oil droplets under water. A) Near-nanoscale droplet with LNPs with the surface stiffness data overlay.[1] B) LNPs of various sizes on the micron-scaled droplet interface. A nanoparticle was suddenly lost from the interface (red arrow) despite the interaction forces being small.

References:

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