Self-faceting of nano- to yocto- liter liquid droplets: from fundamental topology to nanotechnological applications

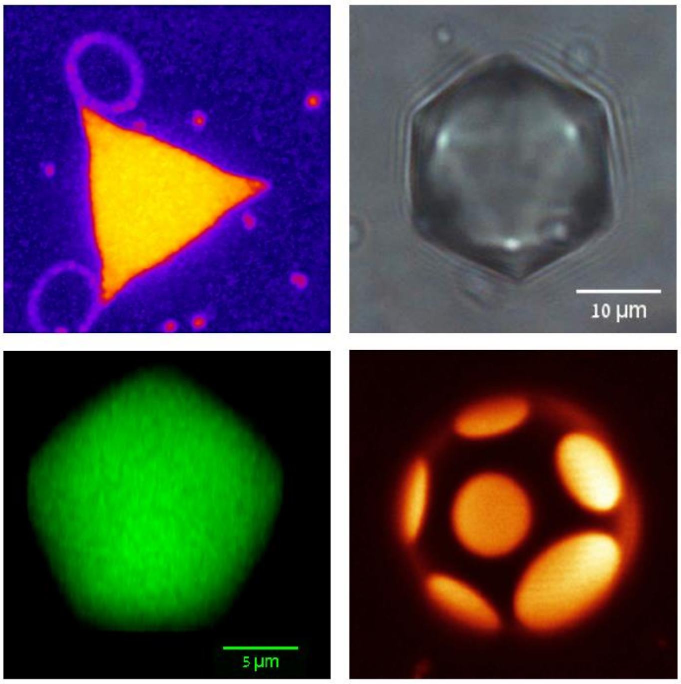
Eli Sloutskin

Physics Dept. and Institute of Nanotechnology & Advanced Materials, Bar-Ilan University

Contrary to everyday experience, where all liquid droplets assume rounded, near-spherical shapes, the temperature-tuning of liquid droplets to faceted polyhedral shapes and to spontaneous splitting has been recently demonstrated in oil-in-water and water-in-oil emulsions[1-2]. These effects occur in a wide range of oil:surfactant combinations, for broad temperature ranges, and in droplets of sizes spanning an incredible 13 decades in volume, from nano- to yocto- liters, suggesting that these phenomena may play a role in a wide range of industrial technologies, where emulsions are employed. Furthermore, droplets' solidification enabled the formation of icosahedral (and other complex-shape) colloidal and nano- particles, unachievable by any other method. However, the mechanism driving these surprising self-faceting phenomena was recently subject to a significant scientific controversy[2].

Our recent experiments, employing simple linear *n*-alkanes and water-soluble ionic and non-ionic surfactants, have resolved the fundamental mechanism driving these phenomena[1,3]. In particular, we have demonstrated that the effect is driven by a few-nm thick monolayer interfacial crystal, self-assembled at the surface of the liquid droplets. This monolayer's closed-surface topology controls the precise shapes adopted by the droplets. Similar mechanisms are suggested to play a fundamental role in shape formation in a wide range of biological systems: from viruses to living organisms.

Furthermore, taking benefit of crystalline monolayers' self-assembly on surfaces of these droplets, we decorate the droplets by precisely self-positioned micro- and nano- particles and molecules, opening new routes towards the self-assembly of complex higher-hierarchy structures.



[1] S. R. Liber *et al.*, *JACS* 142, 8672 (2020); Guttman et al., *PNAS* 113, 493 (2016).
[2] N. Denkov *et al.*, *Nature* 528, 392 (2015).
[3] S. Guttman *et al.*, *Nano Lett.* 19, 3161 (2019).