Nanoemulsification and Phase Inversion: Myths and Realities

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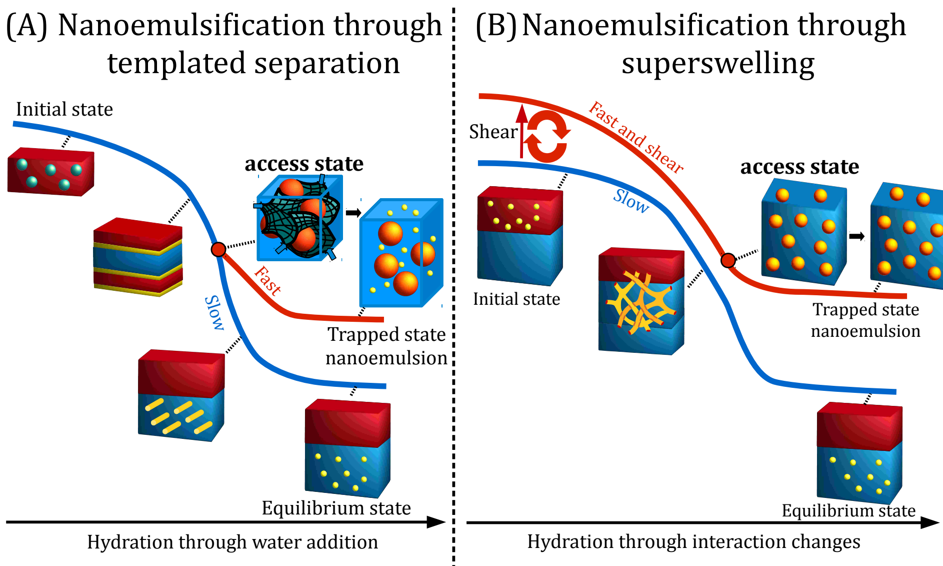
Nanoemulsions represent the ultimate challenge in emulsification due to the large amount of interfaces involved, hence the difficulty to create them and to keep them from disappearing. Rather than applying huge mechanical energies and work with an excess of stabilizers, an alternative is to harvest the free energy of surfactant layers and trap the system along clever pathways. Historically, Shinoda and Saito pioneered this approach in the design of the emulsification by the Phase Inversion method. However, this naming is misleading as we will show that Phase Inversion is totally irrelevant in the emulsification process. Indeed, we demonstrate that the emulsification is occurring in the vicinity of Phase Inversion but at a precise composition/preferred curvature locus [1]. At equilibrium, the oil/water/surfactant system forms bicontinuous networks at this locus. However, a rapid change of the preferred curvature can disrupt the bicontinuous structures and lead to the formation of droplets, the size of which is controlled by the preferred curvature at the locus. This collection of droplets can be then quenched in a metastable state, which yields nanoemulsions. Contrarily to the common belief, modifying the curvature through a change of molecular interactions or through a change of the number of water molecules is not equivalent. We will show that this is due to subtle differences in the bicontinuous structure that is disrupted.

This mechanistic understanding now allows us to bypass the previous constraint of undergoing phase inversion, a dangerous crossing in terms of process design due to, for example, large viscosities change. More dramatically, we will show that in the case of surfactant blends, the only relevant type to industrial applications, a phase inversion pathway is often unsuccessful in producing fine nanoemulsions. To the contrary, starting from the exact locus at which the bicontinuous structures can be disrupted to yield spheres, nanoemulsions with the same properties as with purified surfactants can be obtained. Hope thus arises to further develop these clever nanoemulsification methods for industrial processes.



[1] K. Roger, *Current Opinion in Colloid & Interface Science*, 2016, in press