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Green solubilization and extraction of rare earth elements using Surfactant-Free MicroEmulsions (SFME): Efficiency-microstructure relationship

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Ionic hydrotropes have been recently understood as "nearly self-assembling" weakly surface-active molecules that facilitate solubilization near a miscibility gap. In this work, we try to decipher the behavior of an emblematic ionic hydrotrope: sodium salicylate (NaSal) [1]. The domain of efficiency for solubilization in the single-phase domain is shown on the figure 1. When solubilization efficiency is mapped versus composition, four different domains where hydrotropes are efficient can be identified. Small angle scattering combined with conductivity and self-diffusion coefficients allows to distinguish between these four distinct regimes of efficiency : pre-nucleation clusters (PNC), Ultra-Flexible MicroEmulsions (UFME), weak w/o aggregation and the well-known solubilization near a critical point facilitated by fluctuation.

Surprisingly, these mesostructures are resilient toward the presence of rare earths ions as well as acids, which allows a green liquid-liquid extraction in industrial scale. However, on a macroscopic scale, the phase boundary and the tie-lines shift in salting-in and salting-out, leading to a crossing of the binodals.

[1] A. EL Maangar, Journal of molecular liquids. 310, 113240 (2020)

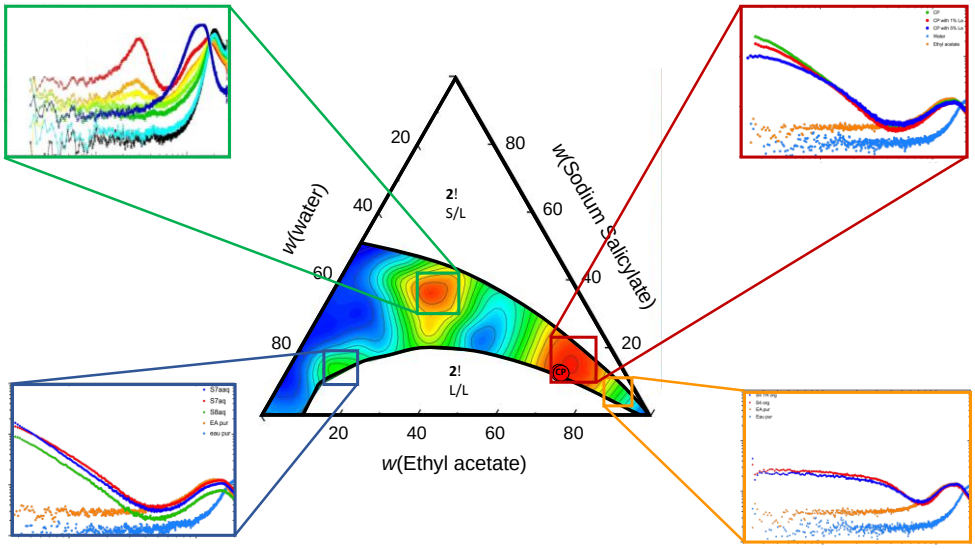

Figure 1 : Phase diagram of water/NaSal/ethyl acetate and associated solubilization regimes of lanthanum in the monophasic region.