Continuous-Flow Reactions in Pickering Emulsions

Supervisor: Valeria Garbin (TP) v.garbin@tudelft.nl
Daily supervisor: Yanyan Liu (TP) y.liu-19@tudelft.nl
Research group website: https://garbinlab.org/

Emulsions stabilized by solid particles (also known as Pickering emulsions) exhibit remarkable stability and have found applications in advanced materials, lightweight composites, encapsulation, food and cosmetics. After the pioneering demonstration that catalytic nanoparticles can be localized at the interface of emulsion droplets [1] (see Figure 1), research in Pickering emulsions for catalysis is now a rapidly expanding area, especially in continuous flow reactors [2]. The overall performance of such applications highly depends on the mass transfer of reactants/products through the interfacial layer of particles, which in turn depends on the surface properties of the particles.

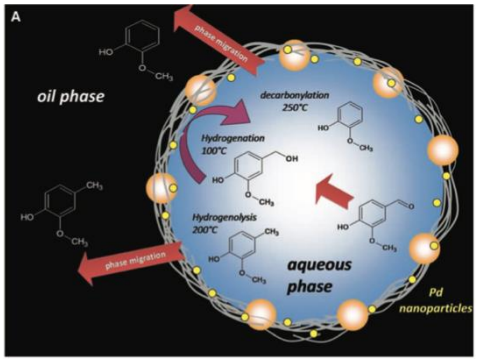

FIGURE 1. Schematic illustration of reactions taking place at the water/oil interface in particle-stabilized emulsions in the first reported demonstration [1].

In this experimental research project, you can choose to focus either on the microscale or on the macroscale. If you are interested in microscale phenomena, you will investigate the effect of the physical properties of particles (e.g., size and wettability [3]) on the formation of liquid-liquid Pickering emulsion; and on the corresponding mass transfer rate of solute from droplet to surrounding phase, and vice versa. If you are interested in the macroscale, your objective will be the behaviour of Pickering emulsions in continuous flow reactor: What are the main factors that control the stability of droplets therein? How to narrow distribution of residence time of the flowing phase? How to extend its operating range (e.g., flow rate and pressure)?

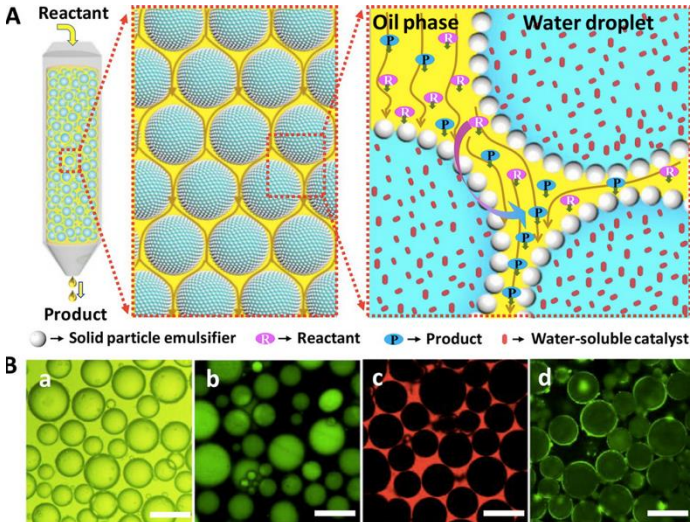

FIGURE 2. (A) Schematic illustration of the Flow Pickering Emulsion strategy for organic–aqueous biphasic catalysis reactions and (B) characterization of the water-in-oil Pickering emulsion [2].

During the project you will master a chemical surface-modification method to prepare particles with controlled wettability, and use a colorimetric method for visualization. Your goal will be to understand the microscopic properties of the particles/droplets and link their dynamics to the performance of the mass transfer or of the continuous flow reactor. Your MEP work will contribute to transforming the empirical-based Pickering emulsion process into a 'smarter design', paving the way to optimized handling of complex, multiphase systems in continuous flow Pickering emulsion.

Background reading:

[1] Crossley et al, Solid Nanoparticles that Catalyze Biofuel Upgrade Reactions at the Water/Oil Interface, Science 327, 68 (2010)

[2] Zhang et al, Compartmentalized Droplets for Continuous Flow Liquid−Liquid Interface Catalysis, Journal of the American Chemical Society 138, 10173 (2016)

[3] Weston, J. S., et al, Silica Nanoparticle Wettability: Characterization and Effects on the Emulsion Properties, Industrial & Engineering Chemistry Research 54(16): 4274-4284 (2015).