**Impact of nanoparticles and surfactants on drop size distribution and phase separation in liquid/liquid systems**

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**Highlights**

* Detailed analysis of nanoparticles and surfactants as emulsion additives.
* Impact of additives on coalescence investigated via transient drop size distributions and phase separation curves.
* Self-similarity of drop size distributions and impact on the separation process.

**1. Introduction**

To optimize industrial processes it is often crucial to know the dispersion and coalescence behaviour, respectively the resulting drop size distribution, of liquid multiphase systems. Nanoparticles or surfactants can be used as innovative additives to reduce the droplet size in agitated multiphase systems and enhance the interfacial area available for mass transfer [1,2]. Beside a high interfacial area, the separation of the phases and a subsequent recycling of components is mandatory for economic efficiency [3]. For both agitated systems and the separation process different modeling approaches exist, but the description of additives often is realized using system-specific fit parameters since their actual impact on dispersion and coalescence is not yet fully understood. Aim of this work is a detailed analysis of liquid/liquid systems with nanoparticles [5, 6] and/or surfactants [7, 8] as additives including a detailed description of the droplet size distributions and their impact on the separation process.

**2. Methods**

Drop size distributions are experimentally determined in-situ in a stirred tank set up using an endoscope measurement technique in combination with an image analysis tool and automated drop detection (SOPAT GmbH). With an external camera, the dynamic phase separation is recorded after agitation stop and the overall separation time and phase separation curves are determined [1]. The system composition is described using the mass fraction of nanoparticles in the dispersed phase and the oil/water ratio α = moil/(moil+mwater).

**3. Results and discussion**

The dynamic behaviour of the Sauter mean diameter after changes in agitation speed are shown in Figure 1 (left). The o/w emulsion consisted of water, n-heptan and different weight percent of fumed silica nanoparticles (HDK H20, Wacker). With rising nanoparticle concentration, the coalescence rate after the reduction of agitation speed clearly diminishes. This is caused by the presence of nanoparticles at the liquid/liquid interface and its increased resistance against deformation [5, 6]. The dynamic phase separation curves after a complete agitation stop are shown in Figure 1 (right). The swarm sedimentation towards its continuous phase is illustrated via the sedimentation curve and the height of the completely coalesced interface via the coalescence curve. Higher particle concentrations clearly lead to higher separation times.



**Figure 1.** Transient Sauter mean diameters in agitated systems (left) and phase separation after agitation stop

(ninitial = 900 rpm) (right) in a water, n-heptane, silica nanoparticle HDK H20 system (o/w emulsions, α = 0.15, T = 20°C).

**4. Conclusions**

Nanoparticles and surfactants are promising additives for homogeneously catalysed liquid/liquid reactions. A detailed analysis of the coalescence behaviour under different flow conditions can be performed using the combination of endoscope measurements and separation curve analysis. Although both additives reduce the coalescence, the mechanisms are quite different due to their adsorption energy, size, shape and molecular structure. With the presented measurements and a detailed analysis of the complete drop size distributions, crucial information for the modeling approaches can be achieved.

**References**

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