Analysis of drop breakage processes in turbulent flow

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Drop breakages occur in many liquid/liquid mixing applications in chemical, pharmaceutical or food industries. Besides the coalescence process, it directly influences the drop size distribution (DSD) which determines the efficiency of these processes.

It is widely accepted in literature that drop breakage happens when the external forces exerted on particles by the continuous phase exceed the internal forces which keep the particle together. Based on this assumption a multitude of theoretical models describing this process can be found in literature. Nevertheless, a reliable prediction of the DSD when varying for example material and process parameters is not possible even if coalescence is completely hindered. This leads to the conclusion that a deeper understanding of the drop breakage process is still needed.

In this work drop breakage in a turbulent flow comparable to the flow field in a stirred tank is investigated by high-speed imaging (see example pictures in Figure 1). A single stirrer blade, mimicking a part of a Rushton turbine is therefore mounted in a rectangular channel and induces drop breakage.

In order to describe the breakage event properly, the breakage probability, the breakage time as well as the deformations and oscillations leading to the breakage event are determined by automated image analysis. Additionally, the resulting Sauter mean diameter and the number and the size distribution of the daughter drops are evaluated.

To quantify the influence of the stabilizing forces, numerous different droplet substances with and without the addition of surfactants were investigated under the variation of the droplet diameter. Additionally, the fluid flow velocity of the continuous water phase was varied to also determine the influence of the external deforming forces.

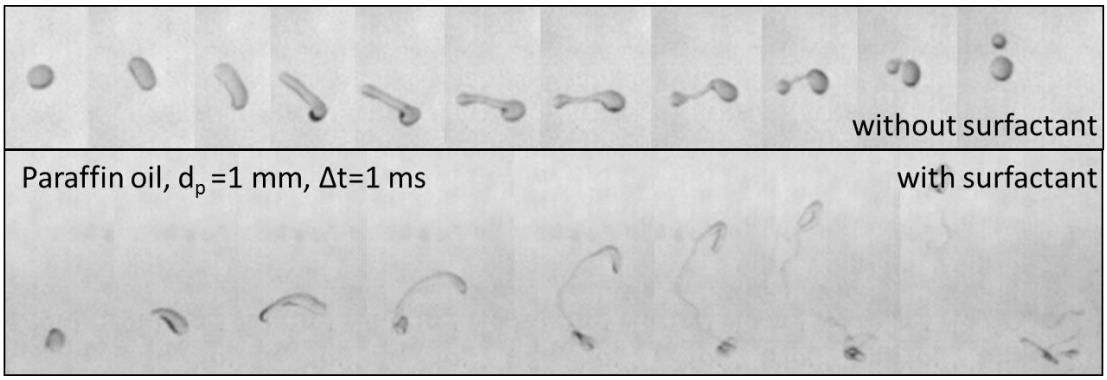


Figure 1: Breakage of a 1 mm paraffin oil droplet in a turbulent flow with different interfacial tensions.

The gained knowledge considering the breakage mechanisms should be scaled up to technical relevant mixing applications. Therefore, experiments in a standard lab scale stirred reactor (6-blade Rushton turbine, d/T=0.33, H/T=1) were conducted. Transient DSD were determined with an endoscope measurement technique and compared to the results of the single drop breakage investigations.