Drop-based modelling of coalescence in batch settlers including polydispersity

David Leleu, Andreas Pfennig

The design of gravity settlers for the separation of liquid-liquid dispersions requires experimental characterization of coalescence behavior of any specific material system of interest, e.g. in lab-scale standardized settling experiments. Such experiments are required, because trace impurities strongly affect coalescence between drops as well as between drops and planar interface. To evaluate such experiments, suitable models and simulation tools are required.

To be able to account for all details acting on the drops during sedimentation and coalescence, a simulation tool based on the ReDrop concept has been developed, which simulates the behavior of dedicated individual representative drops. The behavior of these drops can then be described by drop-based models, which characterize sedimentation and coalescence behavior. For characterization of coalescence, available models have been evaluated. Basis is the work of Kopriwa, who validated experimentally that the individual contributions as depicted in the schematic diagram below depend on either the fluid dynamics of the equipment or the material system. Evaluation of various literature studies revealed e.g. that the contact time as used in previous work was introduced in an inconsistent manner and that on top of the coalescence probability a probability has to be accounted for that the drops bounce when they meet and thus don’t stay in contact at all.

Based on this systematic evaluation, different contributions have been proposed and combined, which allow very generally to describe coalescence under very different boundary conditions in a consistent way. This model has been implemented in a ReDrop simulation tool, which can be used to evaluate lab-scale settling tests and to design batch settlers. First results reveal that coalescence during sedimentation, which has often been neglected previously, has a significant impact on the results. It turns out that for some characteristic systems the drop size, which determines sedimentation, is actually obtained during a ripening process of several seconds, which explains the lag time often found in settling experiments. Also it turns out that the so-called close-packed zone is actually often not closely packed, i.e. that the drops in that zone are actually not in direct contact, which in turn of course influences their coalescence probability. The model concept will be presented together with exemplary simulation results.