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Introduction

The change of raw material from fossil-based to bio-based feedstock will lead to changes in the molecular structure of reagents and products, that will be richer in oxygen. Polar interactions and hydrogen bonding will be present in mixtures. This in turn will lead to lower vapor pressures and higher viscosity. Process design has to account for these changes. The aim of this work is to study some relevant aspects related to liquid-liquid extraction, in order to optimize extraction-column design. With drop-based lab-scale experiments and simulation, extraction-column

design can be time and resources saving compared to conventional pilot-plant based design. This is possible, because appropriate models developed in previous work [1,2] describing the elementary processes occurring during extraction were combined in a simulation tool, called ReDrop (REpresentative DROPs). The appropriate lab-cell measurements are used to validate these models. The ReDrop simulations have been validated for a variety of systems, and the predictions agreed to better than 10% with the experimental data available, [6].

Material & Method

ReDrop concept

A limited number of elementary processes influence the behavior of individual drops of the dispersed phase in an extraction column. The main idea of ReDrop [6] is to follow a sufficiently large number of drops along their path in the column accounting for all of these interconnected phenomena, as shown in Figure 1.

Sedimentation and mass-transfer measurement

Sedimentation velocity and mass transfer have been measured for the EFCE

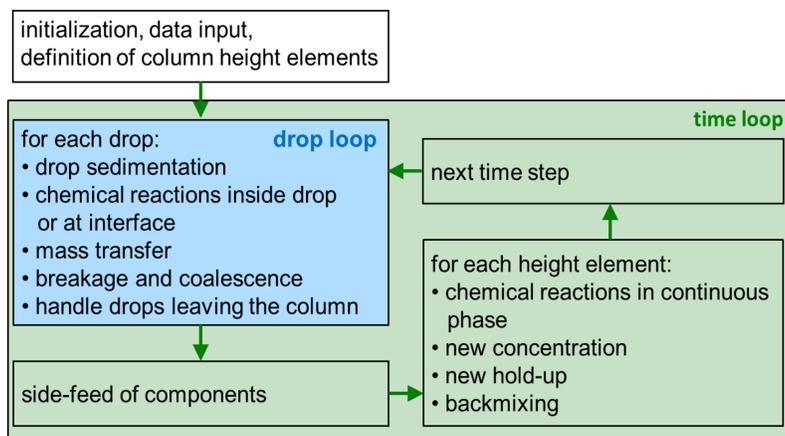


Figure 1. Schematic representation of ReDrop algorithm.

standard test system water + n-butyl acetate + acetone [3]. Sedimentation velocity of single drops is measured recording the path of a single drop rising in a cylindrical glass vessel and then analyzing the video. Single-drop mass-transfer investigations have been carried out in the cell shown in Figure 2. The drop rises in the cell. After the chosen contact time, it is collected and the concentration of transferred component in the drop is then measured.

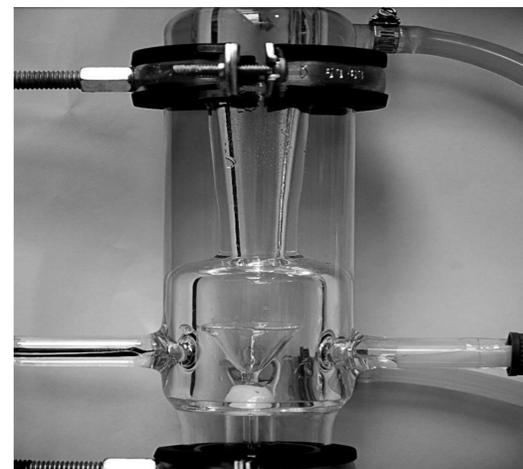


Figure 2. Single drop cell for mass transfer measurement

Results – Discussion

For the sedimentation velocity, three different drop diameters have been investigated. Figure 3 compares the obtained values for sedimentation velocity with the data collected in previous work [4]. It is apparent that the new data match essentially exactly with previous results. Drops of n-butyl acetate in water behave like rigid spheres for the smallest drop diameter. The larger drops investigated behave as spheres with internal circulation, approaching the mobile-interface region. Mass transfer results of this work are reported and compared with previous data in Figure 4. As expected, the dimensionless concentration difference decreases

with contact time. The results in Figure 4 shows that for the drop with smaller diameter faster mass transfer results as expected. This shows that also the mass-transfer cell has been validated and the proper procedures have been established at the University of Liège. Adinata [5] shows that the viscosity of the dispersed phase has a strong influence on sedimentation velocity, while mass transfer seems to be more affected by the viscosity of the continuous phase. In the future work, sedimentation and mass transfer will be investigated by changing the properties of the material system, in order to adapt the models to system with increased viscosity in both phases.

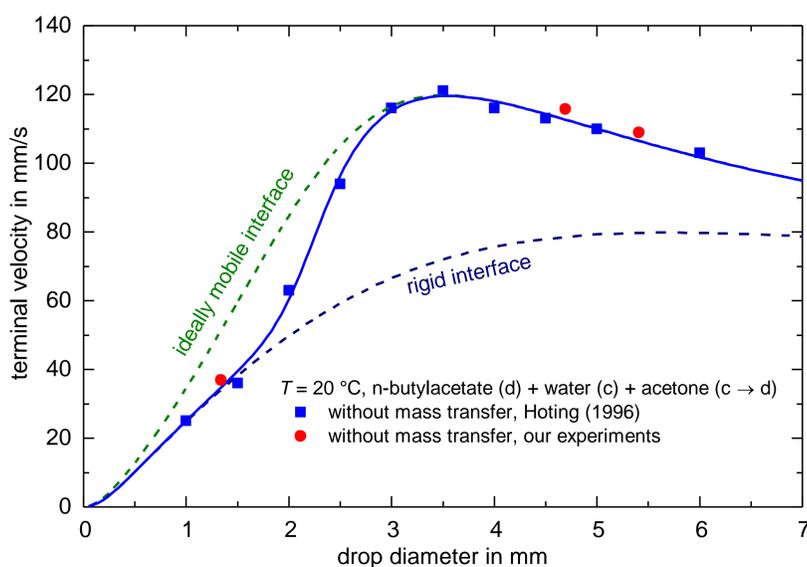


Figure 3. Sedimentation velocity of n-butyl acetate drops in water as a function of the drop diameter.

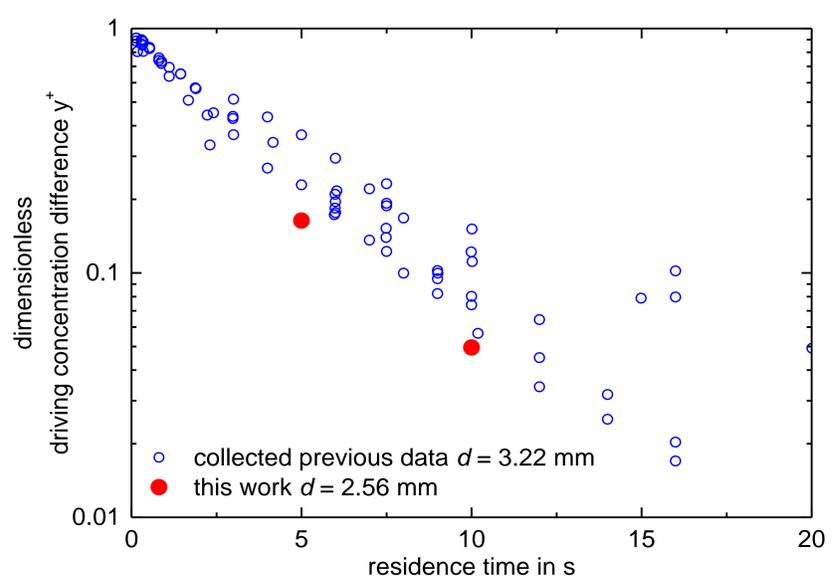


Figure 4. Dimensionless driving concentration difference as a function of residence time.

Conclusions

The validation of the lab-scale equipment to quantify single-drop behavior with the standard test system shows good agreement with previous data. Since the range of viscosity between 1 and 100 mPas has to be investigated in future work, the viscosity of dispersed and continuous phase will be increased by adding suitable compounds. For the aqueous phase, a suitable polymer will be chosen, and the viscosity of the organic phase will be increased by adding paraffin oil. Equilibrium data on this new systems will be collected by performing equilibrium experiments. Sedimentation and mass transfer of single drops will be evaluated as a basis for a further validation of the models developed in previous work [1,4]. The models will be then implemented in the structure of the simulation tool ReDrop.

References

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