

## Effect of Liquid-liquid Interfacial Area on Multiphase Catalysis

M. Schrimpf,<sup>1</sup> K. E. Naße,<sup>1</sup> A. J. Vorholt,<sup>1</sup> W. Leitner<sup>2</sup>

<sup>1</sup>Max Planck Institute for Chemical Energy Conversion, Mülheim an der Ruhr, Germany

<sup>2</sup>Institute of Technical and Macromolecular Chemistry, RWTH Aachen University, Aachen, Germany

### Abstract

The investigation of liquid–liquid interfaces are interesting to investigate, especially for understanding the effect on mass transport between both phases at different parameter and the correlated transport limitations. With a photo–optical probe (also called a borescope) with automated image analysis, we were able to investigate the interface of the liquid phases. The borescope and evaluation algorithm analyze the liquid droplets exclusively without the interference of possible gas bubbles in the emulsion.

This photo-optical probe was applied in multiphase catalysis. A well-known example of multiphase catalysis is the Ruhrchemie/Rhône–Poulenc process for the hydroformylation of short chain alkenes, which are transformed to aldehydes with synthesis gas. In this system, the catalyst is immobilized with a water-soluble ligand in a polar aqueous phase. The product forms a second organic, non-polar phase and can be easily separate afterwards.

For long chain alkenes the reactivity is much lower due to the transport limitation between the phases and the poor solubility of the alkenes in water. There are different approaches in research to improve this limitation. By adding additives such as amphiphilic ligands or by intensifying the stirring for increasing the liquid–liquid interface with various stirrer or reactor designs. Nevertheless, it is still debated where the reaction takes place, at the interface of the polar water phase and non-polar organic phase or with substrate dissolved in the catalyst bulk phase.

The use of borescopy allowed us to investigate the interfacial area in the aqueous multiphase hydroformylation of 1-octene. Different parameters (ligand concentration, nonanal concentration, stirrer speed and catalyst concentration) were tested. A significant influence on the interfacial area by the ligand concentration as well as the product nonanal concentration were found. An up to 5-fold increase in interfacial area was measured. That means, the interfacial area changes constantly during the reaction while nonanal is being produced.

### References:

[1] M. Schrimpf, P. A. Graefe, A. E. Kaczyna, A. J. Vorholt, W. Leitner, *Ind. Eng. Chem. Res.* 2022, 61, 2701–2713.

[2] M. Schrimpf, P. A. Graefe, A. Holl, A. J. Vorholt, W. Leitner, *ACS Catal.* 2022, 12, 7850–7861.

[3] H. Warmeling, R. Koske, A. J. Vorholt, *Chem. Eng. Technol.* 2017, 40, No. 1, 186–195.

[4] H. Warmeling, D. Hafki, T. von Söhnen, A. J. Vorholt, *Chemical Engineering Journal* 326 (2017) 298–307.

[5] H. Warmeling, D. Janz, M. Peters, A. J. Vorholt, *Chemical Engineering Journal* 330 (2017) 585–595.