

Liquid-liquid interfaces in homogeneous catalysis

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Abstract

Homogeneous catalysis offers several advantages over conventional heterogeneous catalysis, including lower reaction temperatures and pressures, well-defined active sites with high selectivity, and ease of modification. However, separating and recycling homogeneous catalysts present significant challenges. One effective approach to address this issue involves using two immiscible liquids, as demonstrated by the Ruhrchemie/Rhône-Poulenc process. In this process, short-chain alkenes, such as propene, serve as the organic substrate phase, while the rhodium catalyst, combined with the water-soluble ligand trisodium 3,3',3''-phosphinotribenzol sulfonate (TPPTS), forms the aqueous phase. This setup facilitates the efficient separation of the catalyst from the product phase ^[1]. To allow the use of longer substrates (>C₅), such as 1-octene, the phase-mixing process can be intensified ^[2,3].

Given that these reactions primarily occur at the interface between the organic and the aqueous phase, it is crucial to perform a detailed examination of this liquid-liquid interface (a_{LL}). For this purpose, we used the photo-optical in-situ method of high-pressure boroscopy within a miniplant setup. This technique allows the real-time recording and analysis of images of the reaction mixture, providing valuable data on droplet population dynamics and enabling the calculation of the a_{LL} at various stages of the reaction. We apply this methodology to investigate the impact of various additives, reactor types and geometries on reaction rates and other key parameters. Through this study, we aim to gain a comprehensive understanding of the process engineering involved in optimizing catalytic interfacial reactions.

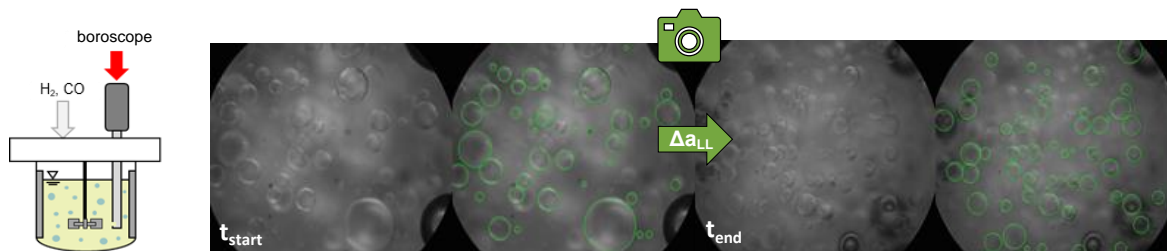


Figure 1: Schematic diagram of the reactor (left). Sample images at the beginning and end of the reaction and their analysis (right).

- [1] M. Baerns, A. Behr, A. Brehm, J. Gmehling, K.-O. Hinrichsen, H. Hofmann, U. Onken, R. Palkovits, A. Renken, Technische Chemie, 2013.
- [2] M. Schrimpf, P. A. Graefe, A. Holl, A. J. Vorholt, W. Leitner, ACS Catal 2022, 12, 7850–7861.
- [3] M. Schrimpf, P. A. Graefe, A. E. Kaczyna, A. J. Vorholt, W. Leitner, Ind Eng Chem Res 2022, 61, 2701–2713.