

Improving Reactivity in Biphasic Hydroformylation of Long-Chain Olefins

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Abstract

Homogeneous catalysis is gaining importance in industrial processes and complements traditional heterogeneous catalysis approaches.^[1] A prominent example is the Ruhrchemie/Rhône-Poulenc hydroformylation process, which uses two immiscible phases: An organic phase containing the substrate and an aqueous phase containing a water-soluble rhodium catalyst complex.^[2] This biphasic system allows efficient catalyst recycling without complex purification steps. While initially applied to short-chain alkenes, recent advances have shown that even long-chain, poorly water-soluble alkenes such as 1-octene can be hydroformylated under intensified mixing conditions. Evidence suggests that the reaction occurs predominantly at the interface between the two liquid phases, emphasizing the importance of understanding and controlling the interfacial dynamics in such systems.^[3-5]

A high-pressure mini-plant with real-time optical imaging was used to study interfacial phenomena during the hydroformylation of 1-octene to nonanal. Image analysis revealed that nonanal formation at 40 mol% increased the interfacial area by up to 322%, but its amphiphilic nature led to accumulation at the interface, reducing its effectiveness.^[3] To counteract this, β -cyclodextrins (CDs) were tested as additives. Due to their hydrophilic outer surface and hydrophobic cavity, CDs enhance solubility and stabilize hydrophobic substrates such as 1-octene through inclusion complex formation.^[6, 7] At the interface, CDs promote the interaction between the olefin and the water-soluble catalyst and release the product after the reaction.^[8] Although the chemical role of CDs in hydroformylation has been thoroughly documented, our investigations were the first to reveal their influence on liquid-liquid interfacial dynamics.^[9] In addition to cyclodextrins, many other additives offer interesting possibilities for improving the reaction rates of hydroformylation of long-chain olefins via interface modifications.^[10]

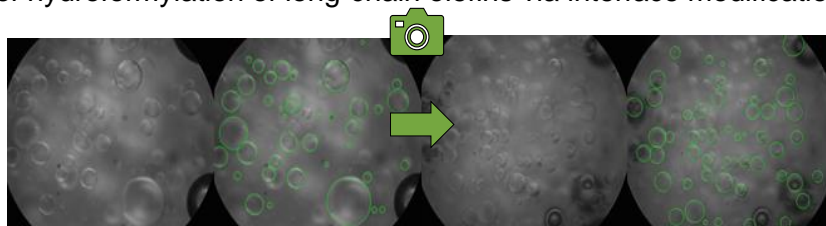


Figure 1 Sample images at the beginning (left) and the end of the hydroformylation of 1-octene and their analysis (right).

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