Selective Hydrogenation in Multiphase Microcapillary Reactors: A Valuable Tool to Harmonize Feedstocks in Lab Scale

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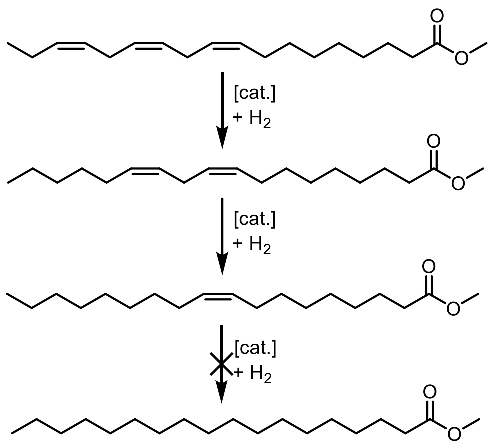
Abstract

Several typically petrochemical reactions can also be conducted with biobased raw materials in order to diversify product portfolios and to enable sustainable chemistry. Examples are hydroformylation and ethenolysis of fatty acid derivatives, amongst others. Selective hydrogenation of polyunsaturated fatty acid derivatives is a crucial step prior to carrying out these reactions with increased activity and selectivity[1]. Thus, feedstocks from different origins with varying degree of unsaturation need to be harmonized to mostly monounsaturated compounds for further utilization.

Combining selective homogeneous catalysts with reaction engineering extends the potential of the applied reaction systems. For instance, microcapillary reactors offer several advantages compared to conventional stirred tank reactors: Especially high surface-to-volume ratios enhance mass and energy transport. A segmented slug flow is a favorable multiphase flow of at least two immiscible fluids, which results in a plug flow reactor-like behavior and an intensified local mixing[2]. Microcapillary reactors also allow for continuous small scale production. To ensure a sufficient supply of the reaction gas, the concept of permeation through the capillary material is applied in this work to keep residence times constant.



Scheme 1: Simplified intended reaction scheme.

The feasibility of this reactor concept for the homogeneously catalyzed selective hydrogenation of fatty acid methyl esters (FAME, scheme 1) is evaluated, especially in terms of mass transport limitations, feeding of reaction gas and in comparison to a standard batch reaction. Furthermore, a one-dimensional cell model is developed to predict the reactor's behaviour.

[1] T. F. H. Roth, A. Kühl, M. L. Spiekermann, H. W. Wegener, T. Seidensticker, ChemSusChem 2024, e202400036.
[2] N. von Vietinghoff, A. Immken, T. Seidensticker, P. de Caro, S. Thiebaud-Roux, D. W. Agar, Chem. Eng. Technol. 2023, 46, 1047.