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Improved Preparation of Cu/Zn-Based Catalysts by Well-Defined Conditions of Co-Precipitation and Aging

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Abstract

Processes that ensure the efficient use of available raw material resources and enable the cross-sectoral application of sustainable technologies are essential for a climate-neutral energy system. For these innovative leaps, the development of active, selective and long-lasting catalysts is a central task of research and development. A knowledge-based catalyst design requires the direct looping of determined functional properties into the material design process and the scalability of the material manufacturing process (Figure 1).

In order to enable science- and knowledge-based adaptation of catalyst materials to new demands, e.g., methanol synthesis from CO_2, a modified method to prepare Cu/Zn-based catalysts based on the strict consecutive execution of co-precipitation and aging is investigated[1].

By successfully stabilizing the initial co-precipitate, two mixing regimes are revealed in the co-precipitation: regarding slow mixing, the particle size of the co-precipitate decreases with increasing volume flow. By contrast, co-precipitation is no longer influenced by mixing for sufficiently high volume flows.

Subsequent aging is essential to obtain the target intermediate zincian malachite by recrystallization from the co-precipitate. Our results indicate that aging can be accelerated by forming smaller aggregates in the co-precipitation. Still, the phase composition at the final aging state could be predicted by a thermodynamic equilibrium alone.

Furthermore, the microstructure of the final catalyst was influenced by co-precipitation and the performance in direct dimethyl ether synthesis was improved by adjusting the mixing in the co-precipitation resulting in methanol productivities of up to 460 $\mathrm{g \cdot h^{-1} \cdot kg_{catalyst}^{-1}}$ [2]. Our experimental setup at the moment allows a production capacity of more than 200 g aged and dried precursor per day when operating the micromixer for approx. 20 min in total. With continuous operation of the micromixer, production rates of well over 500 $\mathrm{g\,h^{-1}}$ of aged intermediate should be possible. We believe that the approach could be scaled-up to the industrial production scale and, hence, is promising to make methanol synthesis from CO_2 more effective and sustainable.

[1] D. Guse, S. Polierer, S. Wild, S. Pitter, M. Kind (2022) *Chem. Ing. Tech., 2022.*

[2] S. Polierer, D. Guse, S. Wild, K. Delgado, T. Otto, T. Zevaco, M. Kind, J. Sauer, F. Studt, S. Pitter (2020) *Catalysts* 2020, 10(8), 816.