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Catalysts and reactors under dynamic reaction conditions for energy storage and energy conversion

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Power-to-X technologies for conversion of electric power into chemical energy play a key role in many concepts for a future energy supply based on renewable sources. A good example is CO2 hydrogenation to methane. Such reactions have extensively been studied under steady state conditions. However, for utilization of power from fluctuating renewable sources the reactors and especially the catalyst systems need to tolerate a dynamic supply of energy and reactants. The response of the catalyst to such dynamic changes is hardly known. [1]
X-ray and neutron based techniques are ideal tools for monitoring structural dynamics of catalysts under changing reaction conditions, i.e. while the catalyst is working. Recently, we studied dynamic changes in the structure and performance of Ni-based catalysts during methanation of CO2 while modulating the H2 supply using operando X-ray absorption spectroscopy (XANES and EXAFS). We observed that an interruption of the H2 feed led to some extent to oxidation of the Ni particles resulting in a deactivation of the catalyst.[2] Further studies using Quick-EXAFS showed that a higher modulation frequency had a less pronounced effect on the catalyst deactivation because oxidation/reduction effects occurred mainly on the surface of the Ni particles.[3]
[1] K. Kalz et al., Chem. Cat. Chem. 17 (2017) 9; SPP-Homepage: www.spp2080.org.
[2] B. Mutz et al., J. Catal. 327 (2015) 48.
[3] B. Mutz et al., Catalysts 7 (2017) 279.

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