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Observing supported nanoparticulate catalysts at work

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Many relevant conversions, such as the production of renewable fuels and platform molecules from CO2 and renewable H2, or the decomposition of natural gas to produce carbon and CO2-free hydrogen suffer from limited catalyst lifetimes. It is essential to understand deactivation mechanisms and how to mitigate them. Recent advances in our group allow in situ or even operando gas-phase transmission electron microscopy to visualize the dynamics and catalytic action of ensembles of many individual supported metal catalysts particles.

For instance, we follow carbon nanofiber growth from NiCu-catalyzed methane decomposition under working conditions, directly comparing the time-resolved overall carbon growth rates in a reactor (gravimetrically) and nanometer scale carbon growth observations.(1) This allow us to understand the influence of particle size and composition on important functionality descriptors such as catalyst lifetime, total carbon yield and structure of the resulting carbon nanomaterials. We also visualized the movement and growth of ensembles of tens of Ni nanoparticles during

CO2 methanation in real time.(2) We observed distinct particle growth mechanisms, depending on interparticle distance, particle sizes, and local support morphology. This allows us to understand the collective catalyst performance based on direction observation and quantification of the behaviour of individual catalyst nanoparticles on the nanoscale under relevant working conditions.

References

[1] S.E. Schoemaker, T.A.J. Welling et al. Catal. Today 2023, 418, 114110; J. Phys. Chem. C. 2023, 127, 15766-15774.; Mater. Adv. 2024 DOI:

10.1039/D4MA00138A

[2] N.L. Visser, S.J. Turner, J.A. Stewart, B.D. Vandegehuchte, J.E.S van der Hoeven, P.E.de Jongh, ACS Nano, 17 (2023), 14963-14973.