In situ ESEM study of supported noble metal nanoparticles dynamics under reaction conditions

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One of the primary deactivation mechanisms of supported noble metal catalyst nanoparticles, such as Pt and Pd on Al_2O_3 or CeO_2, is thermal deactivation via sintering. Although sintering has been extensively studied in the literature, recent debates regarding surface-mediated versus gas-phase-mediated sintering pathways [1] necessitate a more comprehensive investigation. We propose a novel scale-bridging in situ environmental scanning electron microscopy (ESEM) approach, which will enable the collection of statistical data on a micrometer scale, providing new insights into the mechanisms of sintering.

Our experimental setup within the ESEM includes a heating stage capable of reaching temperatures up to 1000°C and a custom-built gas injection system to control the gas atmosphere and flow precisely. This setup will be integrated with automated post-processing routines to facilitate the tracking of the evolution of large populations of supported nanoparticles under reaction conditions, enabling the analysis of nanoparticle behavior as a function of temperature and gas atmosphere.

In this study we will present preliminary results and the developed post-processing routines, focusing on the unique challenges associated with tracking a large number of dynamic nanoparticles under reaction conditions. The development of these methodologies opens up a new method of analysis and is crucial for the accurate study of sintering behavior and for improving our understanding of the deactivation processes of noble metal catalysts.

[1] J. Oh, A. Beck, E. D. Goodman, L. T. Roling, A. Boucly, L. Artiglia, F. Abild-Pedersen, J. A. Van Bokhoven, M. Cargnello, ACS Catal. 2023, **13** (3), 1812–1822. DOI: 10.1021/acscatal.2c04683.