In situ TEM studies of supported palladium catalysts for the oxidation of methane

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Abstract:

Supported palladium particles are used in some of the most active catalysts for methane combustion under lean burn conditions in exhausts and turbine combustors.

Here, we use *in situ* transmission electron microscopy (TEM), *in situ* X-ray absorption spectroscopy (XAS) and catalytic data to gain insight into structure-performance relationships in a flame-synthesized Pd/ZrO_2 catalyst during methane oxidation. XAS is used to provide averaged information, while TEM is used to probe individual nanoparticles and agglomerates. Observing the same tendencies using TEM and XAS *in situ* provides valuable information of the structure, which can then be linked to the performance of the catalyst under working conditions.

Earlier studies, which focused on *in situ* XAS and X-ray diffraction [1], suggested that the reduction of Pd particles takes place rapidly on heating, accompanied by sintering and an associated decrease in catalytic activity leading to a hysteresis during temperature cycling.

By using a differently pumped environmental TEM [2], we are able to study the catalyst at elevated temperature (800°C) in 5-10 mbar of flowing CH_4:O_2 (1:4), while maintaining a spatial resolution that allows atomic planes in both the Pd and the ZrO_2 to be resolved. We observe structural changes of both the Pd particles and their support during heating *in situ* in the TEM. By combining this information with spatially resolved electron energy-loss spectroscopy, we obtain information about the crystal structures, morphologies and electronic structures of individual Pd particles.

References

[1] J.-D. Grunwaldt, N. van Vegten and A. Baiker, *Chem. Commun.* 2007 (2007) 4635.
[2] T. W. Hansen, J. B. Wagner and R. E. Dunin-Borkowski, Materials Science and Technology (2010) in press.