Characterization of Catalysts for Synthesis of Higher Alcohols using Electron Microscopy

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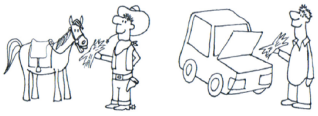
Motivation

The increasing interest in developing transportation fuels from sustainable resources demands new and better production paths, *e.g.* synthesizing alcohols from biogas. Higher alcohols are favorable due to their higher energy density and ease of application in today's internal combustion engines. However, the poor yield of higher alcohols in chemical reactions creates demand to find better catalysts for these applications [1].



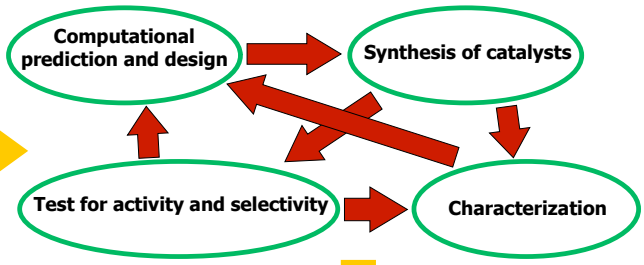
Challenges for catalysts

- Highly active and selective towards higher alcohols
- Chemically and structurally stable under reaction conditions
- Based on earth abundant elements

This project is part of the CAtalysis for Sustainable Energy (CASE) initiative and involves characterization of the designed catalysts using methods available at DTU Cen.

Approach

Systematic development instead of trial and error.

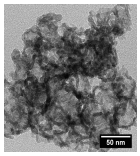


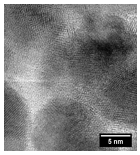
Experimental equipment

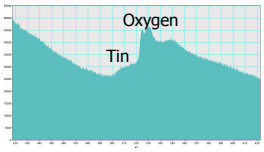
FEI Titan transmission electron microscope equipped with a differential pumping system, an image corrector, an EDX system and a Gatan imaging filter.

Ability to carry out experiments in different gases at elevated temperature:

- Structural analysis (bright field, dark field, diffraction)
- High resolution imaging
- Elemental analysis (EDXS, EELS)
- Z-contrast analysis (HAADF, STEM)



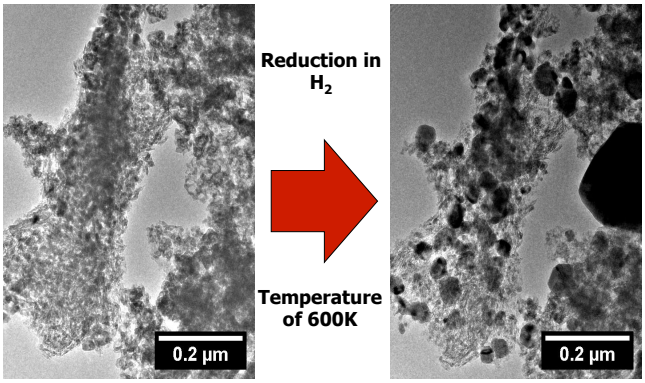




The environmental capabilities together with a heating holder enable us to study catalysts with TEM methods at nearly realistic conditions [2],[3].

First results

CuSn supported on Al_2O_3, reduced in H_2 (1.2 mbar) and heated to a temperature of around 600K.



High vacuum, RT — **H_2 (1.2 mbar), 600K**

- Aglomerates ranging from 200nm to around 2µm
- Crystals of 30–300nm size form reducing the catalyst *in-situ*
- EELS investigation of these crystals shows mainly Cu, Sn is too weak to detect

Outlook

Performing experiments focusing on…

- Structural changes as a function of atmosphere, temperature and time.
- Identifying the promoter for the catalysts

References

[1] J. J. Spivey, A. Egbebi, *Chemical Society Reviews,* **2007**, vol. 36, pp. 1514 - 1528.
[2] A. K. Datye, *Journal of Catalysis,* **2003**, Vol. 216, pp. 144 - 154.
[3] T. W. Hansen et al, *Science,* **2001**, Vol. 294, (5546), pp. 1508 - 1510.

Acknowledgement:

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