

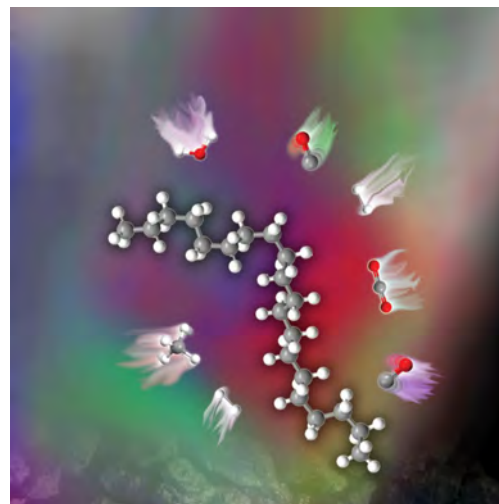
Watching a Catalyst at Work

Catalysts are used to speed up chemical reactions in many industrial applications, including energy storage in fuel cells and batteries, processing and refining oil and gas products, and acting as electrode materials in supercapacitors. The ability to study catalysts under realistic working conditions is an interesting challenge for scientists. To recreate the extreme environments in which many catalysts operate a range of complex temperature, pressure, environmental and chemical conditions must be maintained. Scientists from the Canadian Light Source along with scientists from Utrecht University and the Delft University of Technology in the Netherlands have come up with a powerful new method for studying catalysts using synchrotron techniques.

The use of a specially-designed nano-reactor, along with a synchrotron-based scanning transmission X-ray microscope (STXM), allowed the research group to study the activation of a catalyst, in realistic operational conditions, on the nanometre scale (a nanometre is one billionth of a metre). The high resolution they were able to achieve with the system provided images of a single iron-based catalyst particle during thermal treatment in a hydrogen-gas atmosphere.

The researchers were interested in seeing how a single catalyst particle works, compared to what happens in a large amount of the same catalytic material, as a way of better understanding the catalytic process. The catalyst they chose to look at is one that plays an important role in the synthesis of fuel from coal or biomass, instead of conventional crude oil. The catalyst is a driver of Fischer-Tropsch synthesis (FTS), an industrial process that uses catalysts to make fuel from syngas (a mixture of hydrogen and carbon monoxide) and an initial step in producing fuel from coal or biomass.

Chemist Frank de Groot, from Utrecht University, is one of the researchers on the team that developed the technique. De Groot is extremely pleased with the success of the project, which was recently featured as a cover story in the journal *Angewandte Chemie*. "The experiment depends on a range of complex ingredients that all have to work perfectly at the same time . . . it actually took us four years to get everything working."



Artist's interpretation of a hydrocarbon chain (centre) and smaller reactant molecules on the false-coloured surface of a Fischer-Tropsch catalyst particle. The different colours denote the distribution of different chemical forms of iron.

From de Smit, et al. 2009, *Angew. Chem. Int. Ed.* 48: 3632-3636.

Fast facts:

- Catalysts are used to speed chemical reactions in many industrial processes, such as storing energy in fuel cells and refining oil and gas.
- Using the CLS, researchers developed a powerful new technique to observe how a single particle of a catalyst works at the molecular level, making it possible to study structural changes in a variety of materials and chemical reactions, or examine the activity of nanoparticles inside cells.

Reference: de Smit et al, 2009. Nanoscale chemical imaging of the reduction behavior of a single catalyst particle. *Angewandte Chemie* (International Edition) 48, 20, pp. 3632-3636. DOI: 10.1002/anie.200806003.

While this new technique makes important strides in the field of catalyst chemistry, it is also something that can be used to study other systems in specialized or extreme environmental conditions. De Groot comments, “The main significance of this work is that it shows the possibility to map materials under working conditions with a spatial resolution of 20 nano-metres. This is not limited to catalysts, and it can also be used for many other applications, such as detecting airborne particulates, studying structural changes in hydrogen storage materials, or examining the distribution of medical nanoparticles in cells.”

In the future, these researchers hope to extend their work into three-dimensions. They are currently working towards tomographic imaging of catalytic solids under working conditions – which would allow an even better understanding of the catalytic processes, and help provide even more improvements to current industrial processing methods.

