Topsoe refinery **Research** & **Development**

Keeping Topsoe at the catalyst forefront

Providing refiners with the best catalysts on the market would be impossible without the innovative ideas from Topsoe R&D. Combined with the knowledge obtained from our pilot plant units, catalyst development is essential to providing high-performing, customized solutions.

Topsoe's research facilities in Denmark have more than 50 hydroprocessing pilot plant units with more than 100 catalytic reactors for catalyst screening and process studies, including dedicated client studies. Over time, Topsoe has handled more than 25,000 customer feed samples.

The complexity of the test units varies from simple, once-through units with reactors in series or parallel to advanced single- and two-stage recycle units with online distillation equipment.

The pilot plant units are not lying idle and every year, they accumulate more than 150,000 pilot hours of hydrocracking catalyst and process development tests and more than 250,000 pilot hours of hydrotreating tests.

The key for predicting catalyst performance, given the operating conditions and the required product specifications, lies with using the best kinetic models. Feed properties, e.g. reactivity from the feed database, is used for continuously improving the Topsoe kinetic models to give you the most accurate operational predictions.

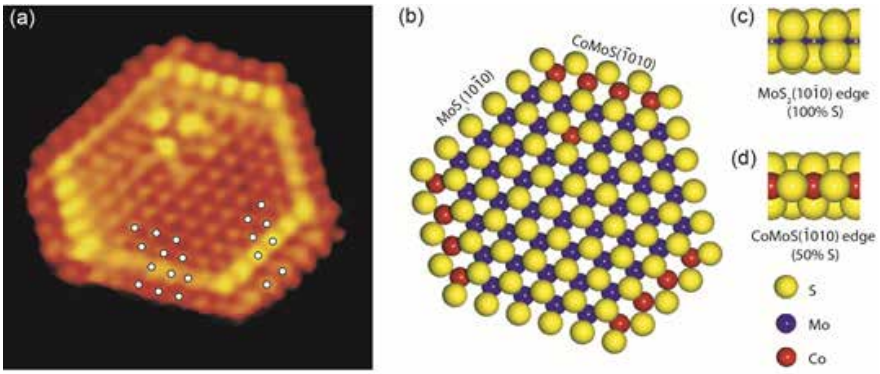
Developing BRIM® and HyBRIM™ technology

Topsoe's microscopy lab holds some of the world's most advanced SEM/TEM microscopies used for both ex situ and in situ studies of catalysts at the atomic level.

In the early 2000s, the presence of activity sites on the basal plane of the CoMo/NiMo sulfided slab was discovered. Using SEM, we were able to take pictures of these new activity sites, which we named brim sites.

Topsoe's latest discovery, designated HyBRIM™, is an improved production technique for both CoMo and NiMo hydrotreating catalysts. It combines the BRIM® technology with an improved catalyst preparation step and is characterized by an optimal interaction between active metal structures and the catalyst carrier.

Scanning electron microscopy of a BRIM® catalyst



Using Scanning Electron Microscopy (SEM) and Transmission Electron Microscopy (TEM), we learned that the electrons of the sulfur atoms located on top of the metal slab one atom layer in from the edge have a much higher density than other sulfur atoms on the basal plane. These high-density sites with almost a metallic character are illustrated as the yellow glowing circle. The difficult sulfur and nitrogen species will be captured by these high-density electronic structures, and the brim sites are responsible for the first stage of the hydrogenation route, depending on the operating pressure. The brim sites also play a key role in the denitrogenation reactions, which, for the most refractive nitrogen compounds, precede the hydrogenation route.

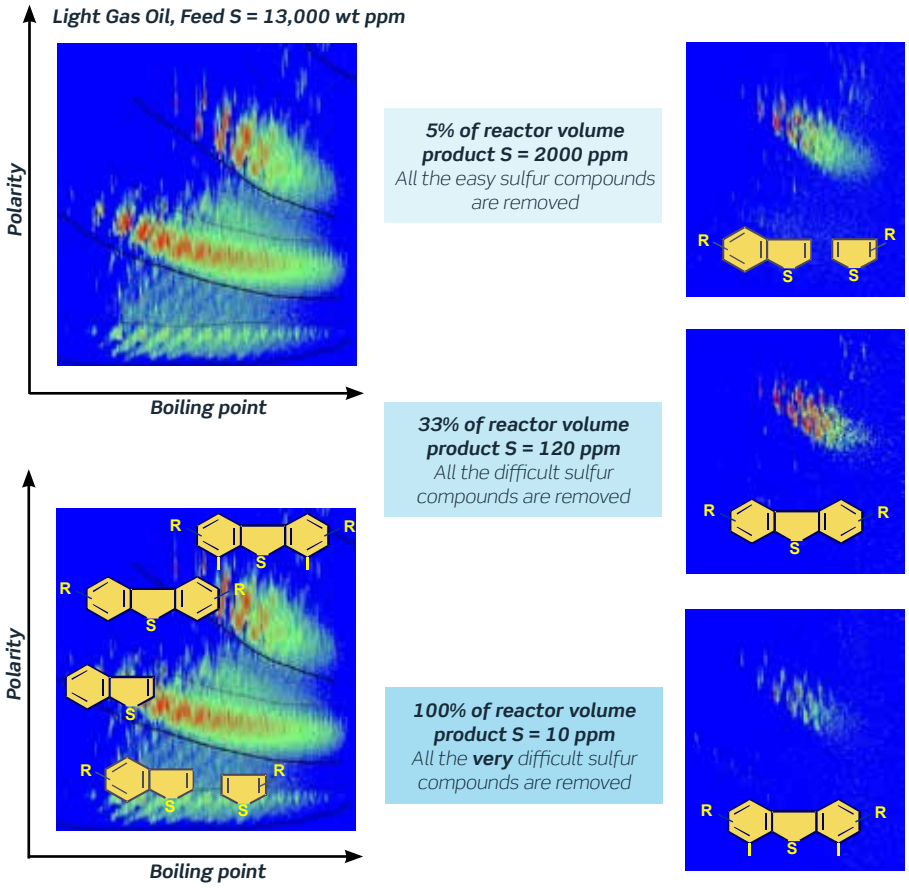
Two-dimensional gas chromatography GCxGC

The GCxGC technique was developed in-house for characterization of oil samples in connection with development and tests of our new products, especially for hydrotreating and hydrocracking catalysts.

Using GCxGC, the desulfurizing of the different sulfur-containing compounds can be followed, and the technique reveals which compounds are the most difficult to remove. The technique is sublime for following the conversion of aromatics, e.g. to establish at which temperatures the aromatics will be saturated and eventually ring-open.

The GCxGC technique increasingly contributes to the understanding of the processes and chemical reactions that take place when hydrotreating or hydrocracking. Using this tool, the processes can be followed on a molecular level, allowing an investigation of reaction paths and detailed kinetics. We use this knowledge in our quest for new and improved catalysts.

HDS as a function of catalyst volume



GCxGC is a method where oil in gas phase is separated in two dimensions. Separation by distillation gives the first dimension, and separation by polarity gives the second dimension, thus allowing for identification of different components with similar boiling points.

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