**Modified catalysts for a low-aromatic Dimethyl ether-To-Gasoline process**

Benjamin Niethammer1, Ulrich Arnold1, Jörg Sauer1

*1Karlsruhe Institute of Technology (KIT), Institute of Catalysis Research and Technology (IKFT)*

*Hermann-von-Helmholtz-Platz 1, 76344 Eggenstein-Leopoldshafen, Germany*

*\*Corresponding author: benjamin.niethammer@kit.edu*

**Highlights**

* Lab-scale investigation of miscellaneous acid zeolite catalysts.
* Catalysts with high selectivity to branched alkanes.
* Catalyst modification for an improved lifetime.

**1. Introduction**

The Dimethyl ether-To-Gasoline (DTG) process employs zeolite catalysts for the production of gasoline from dimethyl ether (DME). DME can be produced from renewable feedstocks, like biomass. This enables gasoline synthesis in a closed CO2 cycle. Established DTG approaches generate a highly aromatic liquid product fraction. Due to their high octane numbers, aromatics can be used as anti-knock additives for gasoline, without increasing the oxygen content and lowering the heating value. On the other hand, aromatics are known to be precursors of soot formation in the engine combustion chamber. One approach to counteract this effect could be a change of the fuel composition to a reduced aromatics content in gasoline. Thereby, the reduction of greenhouse gases and the reduction of harmful particulate emissions in the transport sector could be addressed hand in hand. The intention of this work is to modify the DTG process to a low aromatic content and a large fraction of highly branched alkanes in the product spectrum [1].

**2. Methods**

Catalytic tests were performed in a continuously operated laboratory plant. DME, synthesis gas (H2 and CO) and the inert gases N2 and He can be fed as educt streams in a fixed bed reactor. The gaseous products of the catalytic conversion are transferred through a heated pipeline to a gas chromatographic (GC) online analysis. The GC (Agilent 7890) is equipped with a flame ionization detector (FID) and a thermal conductivity detector (TCD). Thereby, the educt conversion can be determined and an overview of the catalyst selectivity can be obtained. Subsequently, the gas stream is transferred into a cold trap, where the hydrocarbons in the range C5+ are liquefied. Analysis of the composition of the liquid samples is then carried out via gas chromatography according to the ASTM D6730-01 (2016) standard test method.

**3. Results and discussion**

Different acid zeolite morphologies were tested in the lab-scale plant. The catalysts were assessed and compared regarding their selectivity to non-aromatic C5+ components. The main focus was to increase the content of highly branched alkanes, with high octane numbers, in the boiling range of gasoline. Promising zeolite types were identified, but these catalysts revealed only short lifetimes.

The conversion of DME to hydrocarbons is shown in equation 1, whereby -[CH2]- represents the average composition of the product spectrum.

CH3OCH3 → 2 -[CH2]- + H2O (1)

Consequently, the reaction comprises the formation of unsaturated components, which can as precursors of coke deposits that deactivate the catalyst. To improve the lifetime, modified zeolite catalysts were prepared and tested. The zeolites were loaded with hydrogen-active metals and H2 was added to the educt feed. Thus, the formation of unsaturated hydrocarbons is reduced or prevented in the DTG chain-growth mechanism and alkanes (CnH2n+2) can be formed without organic byproducts, as shown in equation 2.

CH3OCH3 + H2 → CnH2n+2 + H2O (2)

 The lifetime of these catalysts clearly exceeded that of the unmodified catalysts, while maintaining or even improving the favorable product selectivity.

**4. Conclusions**

Modified zeolite catalysts that are able to incorporate co-fed H2 into the chain-growth mechanism of the DTG process can improve the catalyst lifetime and the selectivity during the reaction with the intent to increase the content of branched alkanes in the product spectrum.

**References**

1. B. Niethammer, S. Wodarz, M. Betz, P. Haltenort, D. Oestreich, K. Hackbarth, U. Arnold, T. Otto, J. Sauer, Chem. Ing. Tech. 90 (2018) 99–112.