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# High Throughput Catalyst Optimization Program for the GTL-Technologies Methanol-to-Gasoline (MTG), Higher Alcohol Synthesis (HAS) and Fischer-Tropsch-Synthesis (FTS)

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## Abstract

The limited availability and ever increasing cost of crude oil make alternative GTL processes for fuel production based on synthesis gas more and more attractive. The development of improved catalytic processes for MTG, HAS and FTS is especially attractive for the refining industry, and synthetic clean fuels can be tailored to the specifications defined for gasoline, diesel and jet fuels.

Although all three processes have been well known to the industry for decades now, the development of improved catalysts with high productivity, minimum decay and optimum hydrocarbon selectivity is a real challenge for catalyst synthesis as well as for catalyst testing.

State-of-the-art catalysts described in the open and patent literature comprise H-ZSM-5 and other zeolites for MTG, alkalized Co/Ni/Fe-Mo/W-Sulfides or mixed metal oxides for HAS and supported cobalt catalyst for FTS.

In all processes synthesis gas (or methanol from synthesis gas) is converted to complex hydrocarbon product mixtures, with carbon numbers from $C_1$-$C_5$ for HAS, $C_1$-$C_{10}$ for MTG with ZSM-5 based catalyst or $C_1$-$C_{100}$ for Co-based FTS-catalysts. The reaction pressures and temperatures are between 5 – 150 bar and between 250 and 400 °C respectively. Additionally, these processes require optimized in-situ activation procedures (reduction, sulfidation, regeneration).

In this paper the challenges of addressing these demanding GTL reactions with “high-throughput experimentation” will be discussed, along with the current solutions and test protocols pioneered by *hte AG*. The fitness for use of the FTS test protocol will be illustrated by a case study describing the preparation and testing of Co-alumina based FTS-catalysts. The hydrocarbon selectivity (ASF-Plot, O/P vs. carbon number) can be calculated directly from the on-line GC – analysis of the gas phase products. The characterisation of the heavier $C_{13+}$ hydrocarbon FTS-products is based on the analysis of the liquid condensate drained off from a hot gas, high pressure trap. Combination of the differential gas-phase and integral liquid hydrocarbon product rates, allows for calculation of fully mass balanced hydrocarbon product distributions and ASF-plots in the carbon number range between $C_1$-$C_{50}$. The control of these conditions in experiments for 1-3 months time-on-stream allows for simultaneous measurement of the kinetics (decay) of 16 FTS-catalysts under industry-relevant conditions (high conversions, productivities) with high accuracy and precision.

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