Challenges for Petrochemicals and Fuels: Integration of Value Chains and Energy Transition
DGMK Conference October 10 – 12, 2018, Berlin, Germany

Modified Zirconium Oxide Catalysts for Effective Conversion of Carbon Dioxide into Useful Liquid Compounds

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Abstract

Energy supply is the key task of the 21th century. Hence, the development of new resource-efficient processes is necessary to provide energy in the future. In this context a consortium of academic partners from Dresden University of Technology, Freiberg University of Technology and Fraunhofer-Institute IKTS Dresden in the frame of the DELTA-project was set up. One of the project aims is to develop novel heterogeneous catalysts for production of liquid fuels derived from carbon dioxide (GtL = Gas to Liquid technology). Today, there are two main GtL technologies: the production of oxygenate liquid compounds (methanol, dimethyl ether or methyl formate), and the Fischer-Tropsch synthesis for production of high quality middle distillates (i.e. diesel fuel), base-oil, or waxes. In the last decades due to technical, social and economic scenario, the GtL technology for production of synthetic fuels via conversion of carbon dioxide from various feedstocks was favoured.

The main objectives of the project can be summarized as follows: Different series of novel catalyst systems are to be prepared. The resulting catalyst samples are being physico-chemically analysed by a broad range of characterization methods (X-ray diffraction, differential thermal analysis coupled with IR, N_2-adsorption, DRIFTS or FTIR, Temperature-programmed ammonia desorption (TPAD)) to identify the nature of active sites and to characterize the thermal stability, the surface and pore size as well as the kind of interaction of carbon dioxide with active sites. Finally, an evaluation of the catalyst samples is performed to identify the reaction parameters for optimal performance. The expected findings of this proposed research result in an improved catalyst system for the desired carbon dioxide conversion.

In this context, a series of novel ZrO_2-based supported catalysts were synthesized, appropriately modified first with sulfate anions and second using active metal as a surface and other metal as a structural promoter, leading to the general formulation M-P/O-ZrO_2 (M, P, O denotes the active metals, the surface and structural modifiers). In multi-component systems the second metal and the surface promoter influence the catalytic properties of the active metal changing dispersion and electronic properties or may even be directly involved in the reaction. Moreover, oxide supported highly dispersed metals provide opportunities for new structural, catalytic and chemisorptive properties which are not present in the single oxide catalytic systems. The main objectives and expected results of this work are the preparation of doubly promoted nano-composite catalysts exhibiting high catalytic activity, selectivity as well as long-time stability towards oxygenate liquid compounds at medium temperatures and pressures using carbon dioxide derived from regenerative bioresources.