Petrochemistry and Refining in a Changing Raw Materials Landscape
DGMK Conference October 9 – 11, 2017 in Dresden, Germany

Design and Evaluation of a Power to Liquid Process for the Production of Valuable Hydrocarbons from CO_2 and H_2O

G. Herz, E. Reichelt, M. Jahn
Fraunhofer IKTS, Fraunhofer Institute for Ceramic Technologies and Systems, Dresden, Germany

Abstract

Due to the worldwide efforts towards the utilization of renewable energy the share of renewables in electricity generation is increasing. In order to transfer the whole energy system it is necessary to use this electricity in other sectors. A technology allowing this so-called sector coupling is the high temperature electrolysis. In contrast to other electrolysis technologies it allows the direct production of syngas from H_2O and CO_2 (co-electrolysis) and is therefore advantageous for the coupling with synthesis processes. So far most of the proposed process concepts for the coupling of high temperature electrolysis and chemical synthesis are focused on petrol and diesel fractions as products. While easy to store and distribute they are in strong competition to mineral oil products. Therefore, this is focused on the production of high-value products (higher alcohols, waxes) from the coupling of high temperature electrolysis and Fischer-Tropsch synthesis.
Several different approaches for the implementation of high temperature electrolysis or SOEC in a power to liquid process are modeled using the flowsheet based simulation package Aspen Plus. Overall efficiencies for each model were calculated and compared. It is shown that the overall process efficiency is highly dependent on heat integration and by-product recirculation. Additionally, the possibility of direct syngas production via co-electrolysis makes an additional reverse water-gas shift step redundant and leads to a significant increase in energetic efficiency.
For the most promising plant design the boundary conditions of the main process steps were varied in order to find an optimal operating point. Results show that due to the high degree of heat integration and multiple schemes for by-product recirculation a high energetic efficiency of $\eta_{en} > 0.55$ can be reached under realistic conditions and with thermal losses considered. An economic feasibility study reveals that by shifting the product spectrum towards higher valuable products and by simplifying the plant complexity economic feasibility can be significantly improved compared to state-of-the-art processes. The modeling results also show that the feasibility of an electrolysis-based process is also highly dependent on the political framework.