Karlsruhe Institute of Technology

IKFT - Institute of Catalysis Research and Technology

Influence of variable $CO/CO_2/H_2$ synthesis gas in the direct DME synthesis

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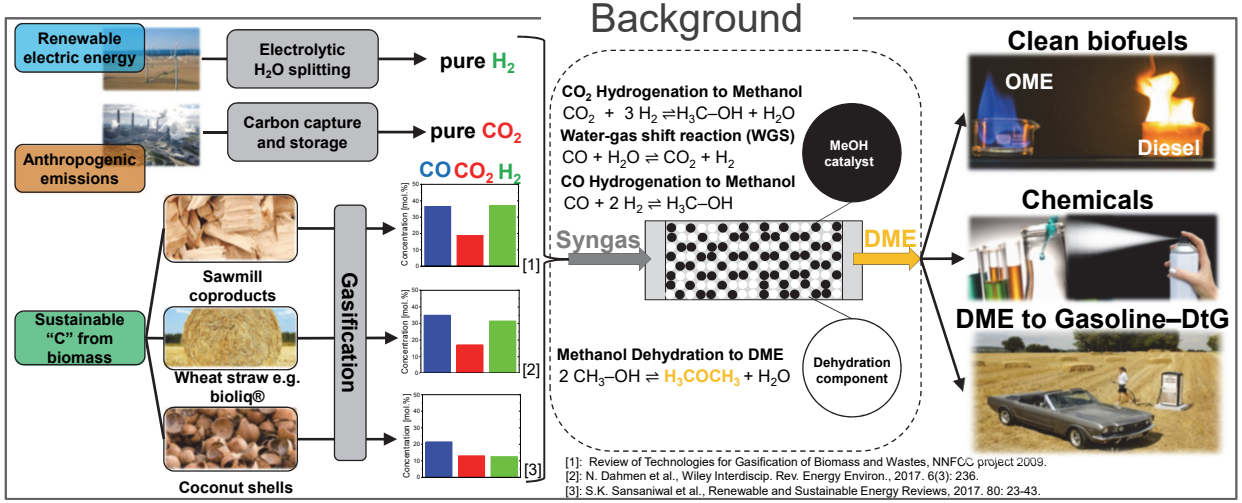
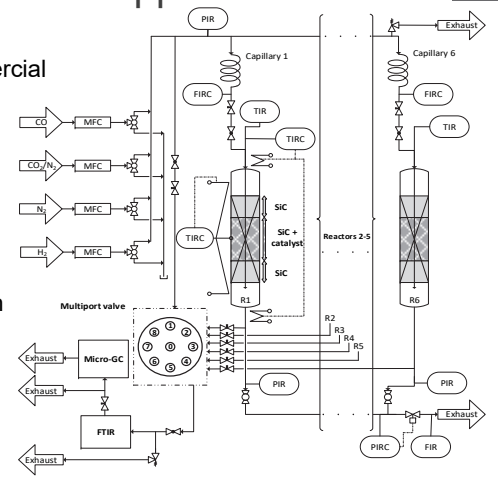
Background



[1]: Review of Technologies for Gasification of Biomass and Wastes, NNFCC project 2009.
[2]: N. Dahmen et al., Wiley Interdiscip. Rev. Energy Environ., 2017. 6(3): 236.
[3]: S.K. Sansaniwal et al., Renewable and Sustainable Energy Reviews, 2017. 80: 23-43.

Experimental approach

- In-house prepared MeOH catalyst: $CuO/ZnO/ZrO_2$ (CZZ) [4] and commercial $CuO/ZnO/Al_2O_3$ (CZA)
- Commerial dehydration catalysts: γ-Al_2O_3 and H-FER 20 (FER)
- Temperature: 210 – 260 °C
- Pressure: 30 to 50 bar
- $GHSV_{cat}$: 5300 to 12300 h^{-1}
- Catalyst and parameter variation in single pass reactor (lab-scale) and 6-fold tube reactor plant (see flow chart):



[4]: S. Polierer et al., *Catalysts*, 2020, 10.
[5]: S. Wild et al., *RSC Advances*, 2021, 11, 2556-2564.

Results

Influence of reaction parameters

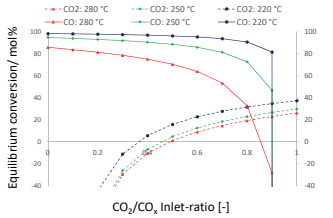


Fig. 1: Influence of CO_2/CO_x inlet-ratio on CO and CO_2 equilibrium conversion with increasing temperature

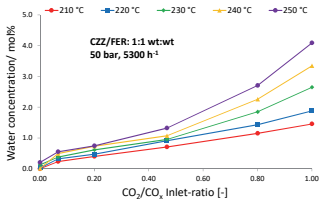


Fig. 2: Influence of CO_2/CO_x inlet ratio on produced water concentration with increasing temperature

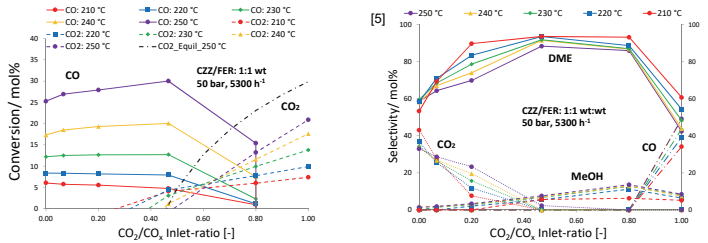


Fig. 3: Influence of CO_2/CO_x inlet-ratio on CO and CO_2 conversion (left) and selectivity (right) with increasing temperature at 50 bar, 5300 h^{-1}, CZZ/FER: 1:1 (wt:wt)

Catalyst investigations

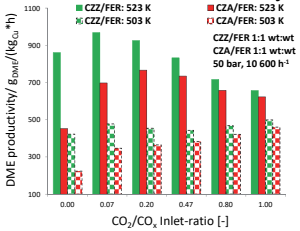


Fig. 4: Comparison of in-house prepared CZZ catalyst with commercial CZA under varying CO_2/CO_x inlet-ratio

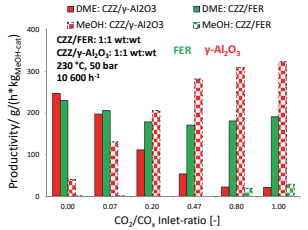


Fig. 5: Comparison of FER and γ-Al_2O_3 under under varying CO_2/CO_x inlet-ratio

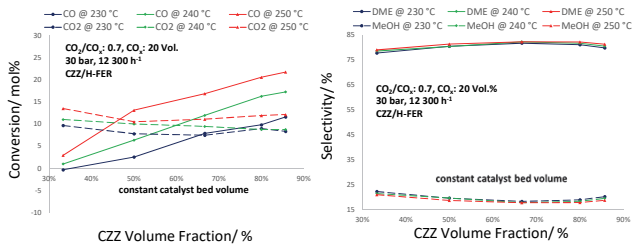


Fig. 6: Influence of CZZ/H-FER ratio on CO and CO_2 conversion (left) and selectivity (right) at elevated CO_2/CO_x feed ratio: 0.7, 30 bar, 12300 h^{-1} at different temperatures

Objectives

- Study of the role of CO_2 in the direct DME synthesis.
- Investigation of different MeOH-forming catalyst systems as well as dehydration components with regard to dynamic/various reaction conditions.
- Optimization of DME productivity by varying the ratio of active components for a selected catalyst system.
- Long-term stability investigation and deactivation studies under different operating conditions.

Conclusions

- Even at low CO_2/CO_x feed ratios, the use of FER shows increased DME productivity compared to γ-Al_2O_3.
- The combination of CZZ/FER enables adaptation to dynamically changing compositions of the synthesis gas feed.
- In particular, at CO_2/CO_x ratios between 0.4 and 0.8 high DME selectivities between 80 and 95 mol% can be realized.
- With FER, the DME production is not limited up to CZZ bed-volume fractions of 86 % (at constant bed volume).