Catalytic Aspects of Sorption-Enhanced DME Synthesis

www.ecn.nl
P.O. Box 1
1755 ZG Petten
The Netherlands

Authors

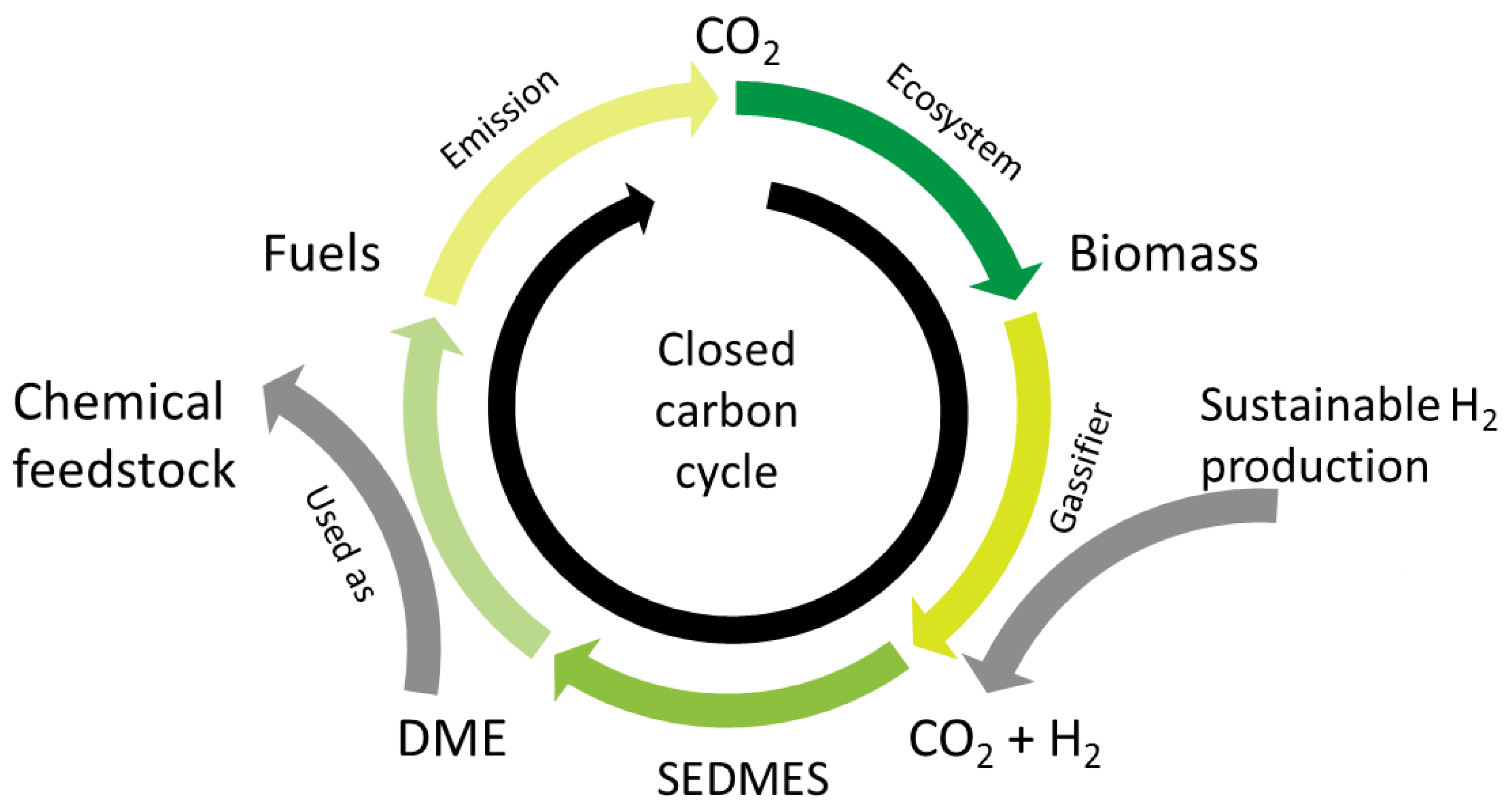
J. van Kampen[1,2], S. Booneveld[1], J. Boon[1,2], M. van Sint Annaland[2]

Corresponding author: vankampen@ecn.nl

Introduction

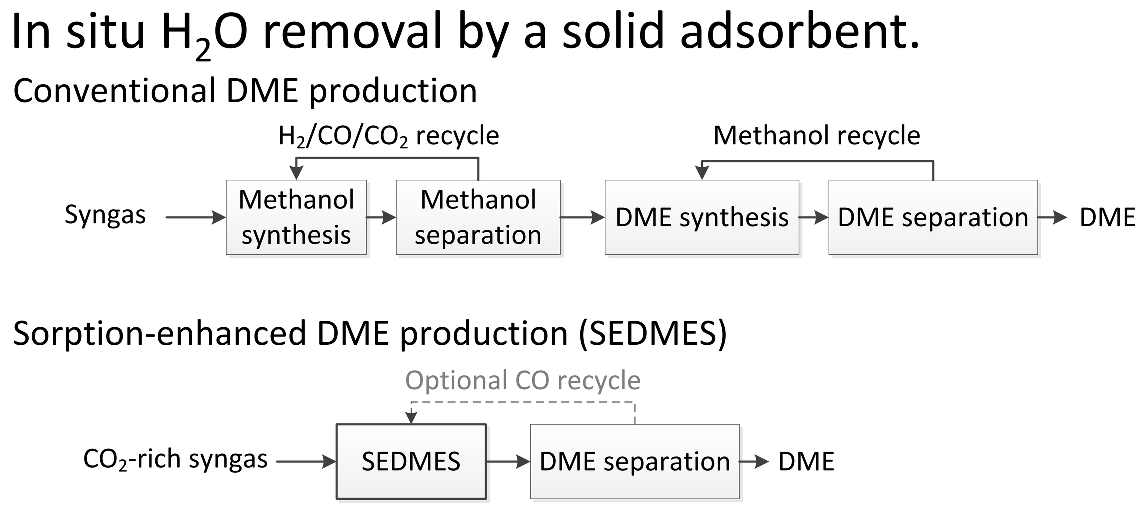
EU Horizon 2020 project FLEDGED combines flexible sorption-enhanced processes to produce dimethyl ether from biomass with an efficient and low cost process.

- DME: one of the most promising alternative fuels under consideration worldwide.
- Sorption-enhanced DME synthesis (SEDMES) is a novel process for the direct production of DME from synthesis gas.
- CO_2 could be utilised directly or via biomass conversion.
- Sustainable hydrogen production from renewable energy sources could be included, supporting Power-to-Product conversion.



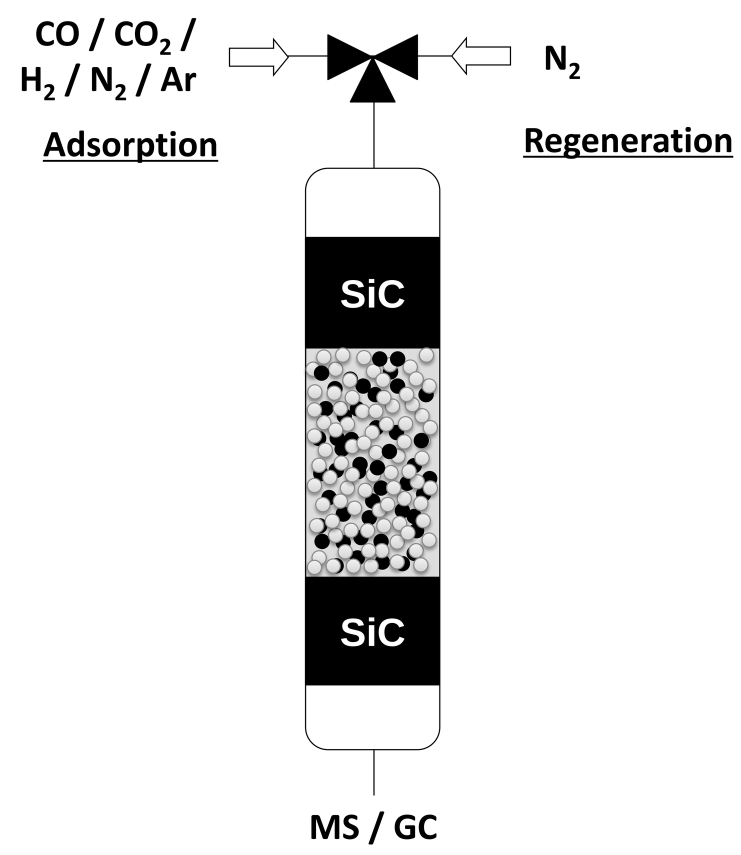
Sorption-enhanced production

- Methanol synthesis: $CO_2+3H_2 \rightleftharpoons CH_3OH+H_2O$
- Water-gas shift: $CO+H_2O \rightleftharpoons H_2+CO_2$
- Methanol dehydration: $2CH_3OH \rightleftharpoons CH_3OCH_3+H_2O$
- SEDMES: In situ H_2O removal by a solid adsorbent.



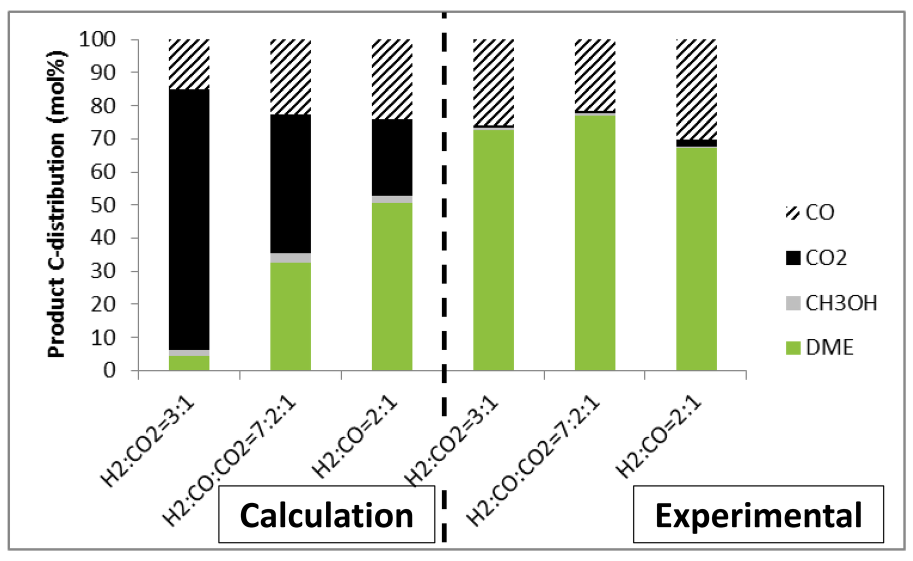
Methods

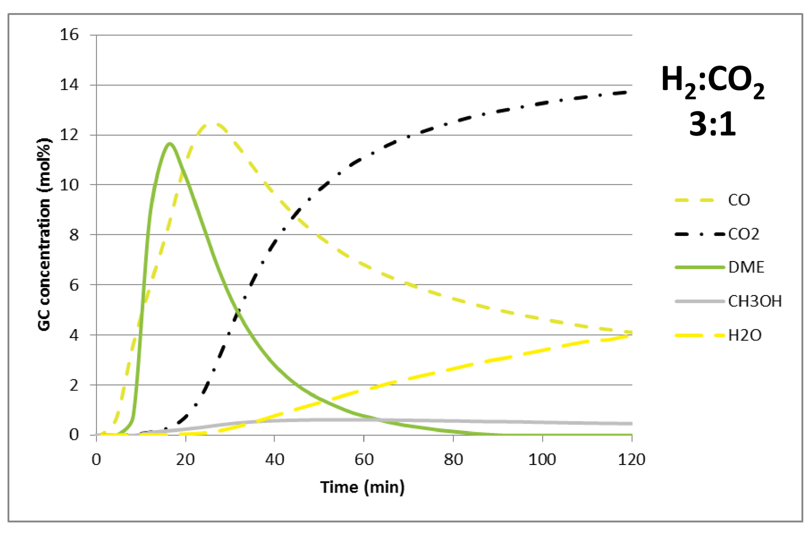
- Adsorption at 275°C & 25 bar(a).
- Regeneration at 300°C or 400°C & 3 bar(a).
- 5 g Copper/Zinc Oxide/Alumina (CZA) catalyst & 21 gram zeolite A adsorbent, well mixed.
- Various feed mixtures of CO_2, CO and H_2 in inert N_2 & Ar.
- $M = ([H_2]-[CO_2])/([CO]+[CO_2]) = 2$

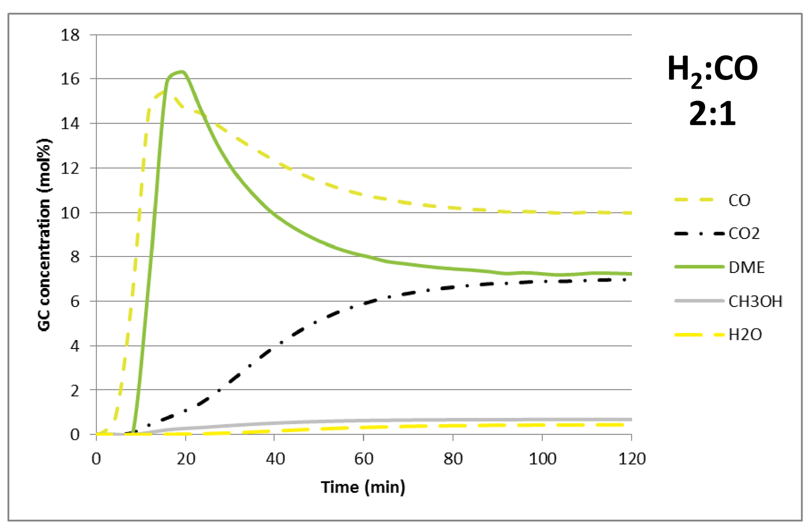


Feed flexibility & Carbon efficiency

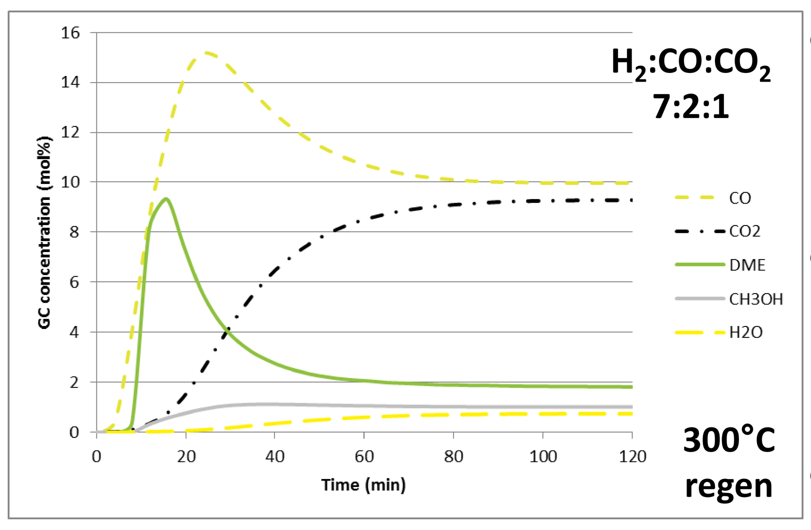
- Pre-breakthrough of steam: CO & DME primary products.
- Similar enhancement effect for various feed compositions.
- Conventional direct DME synthesis 4-50% DME C-yield.
- With SEDMES 65% and more.
- Product CO_2 reduced to <2%.

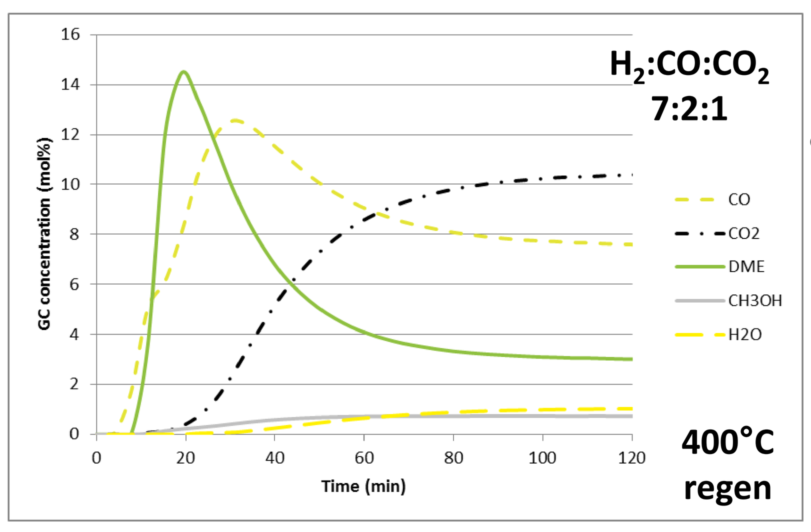






Catalyst functionalities





- CZA catalyst active for water-gas shift, methanol synthesis & dehydration.
- Low DME concentration, and CO_2 & methanol breakthrough when the adsorbent is fully saturated.
- Temperature swing regeneration: breakthrough time extended & higher conversion to DME before steam breakthrough.
- Higher conversion to DME after steam breakthrough: catalyst activity to DME increased by additional temperature swing regeneration.

Conclusion

- Experimental proof-of-concept for the novel SEDMES process is presented.
- Very high carbon to product efficiency is achieved. Simplifying costly downstream separation and recycle.
- Feed flexibility of the SEDMES process makes CO_2 utilisation (direct or via biomass) possible compared to conventional DME production.
- Multifunctional catalyst and sorbent system is key to performance optimisation.

Acknowledgements & Partners

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[1]Sustainable Process Technology, ECN, P.O. Box 1, 1755 ZG Petten, The Netherlands.
[2]Chemical Process Intensification, TU/e, P.O. Box 513, 5600 MB Eindhoven, The Netherlands.