

Catalytic Aspects of Sorption-Enhanced DME Synthesis

Authors

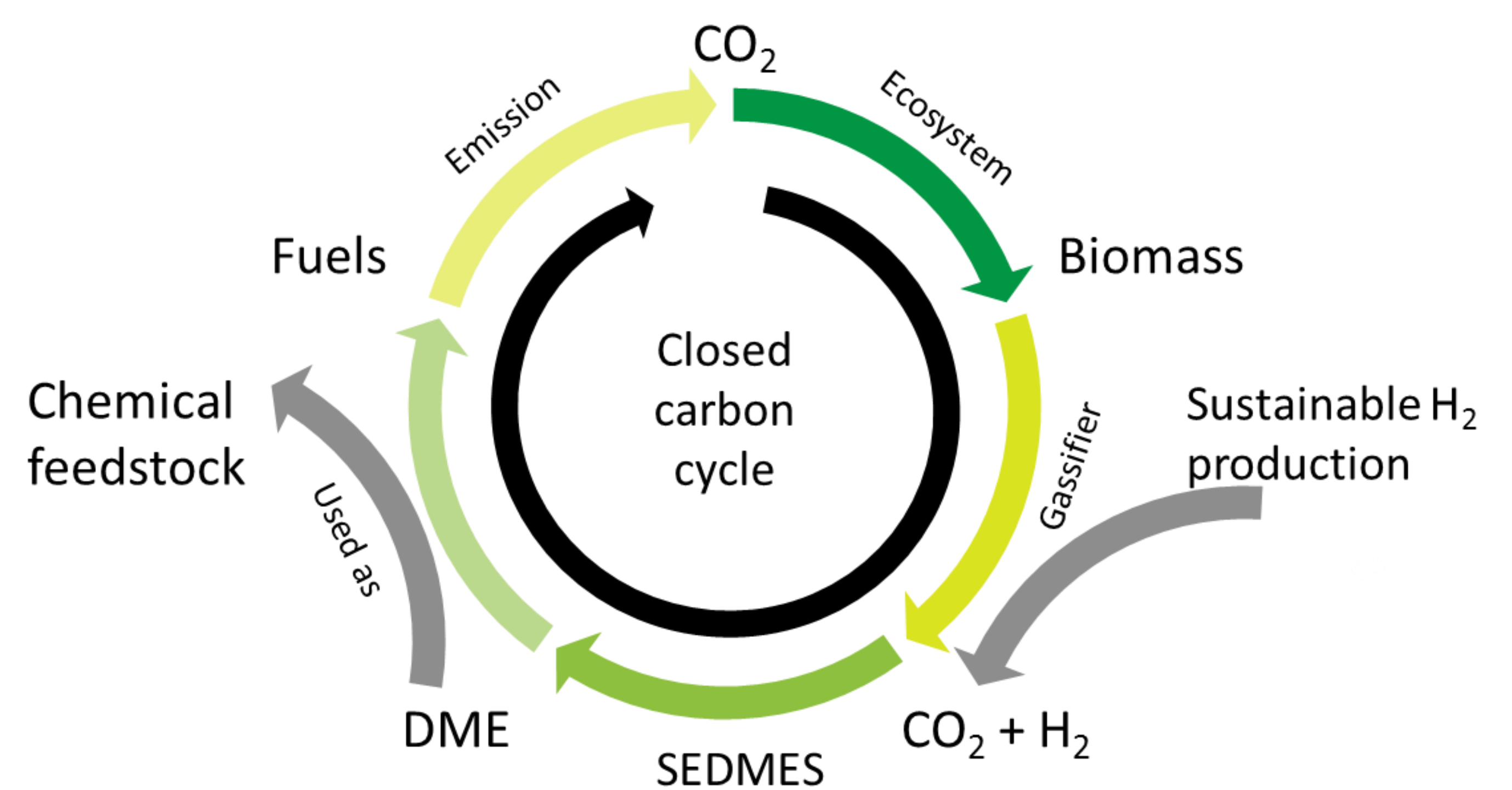
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Introduction

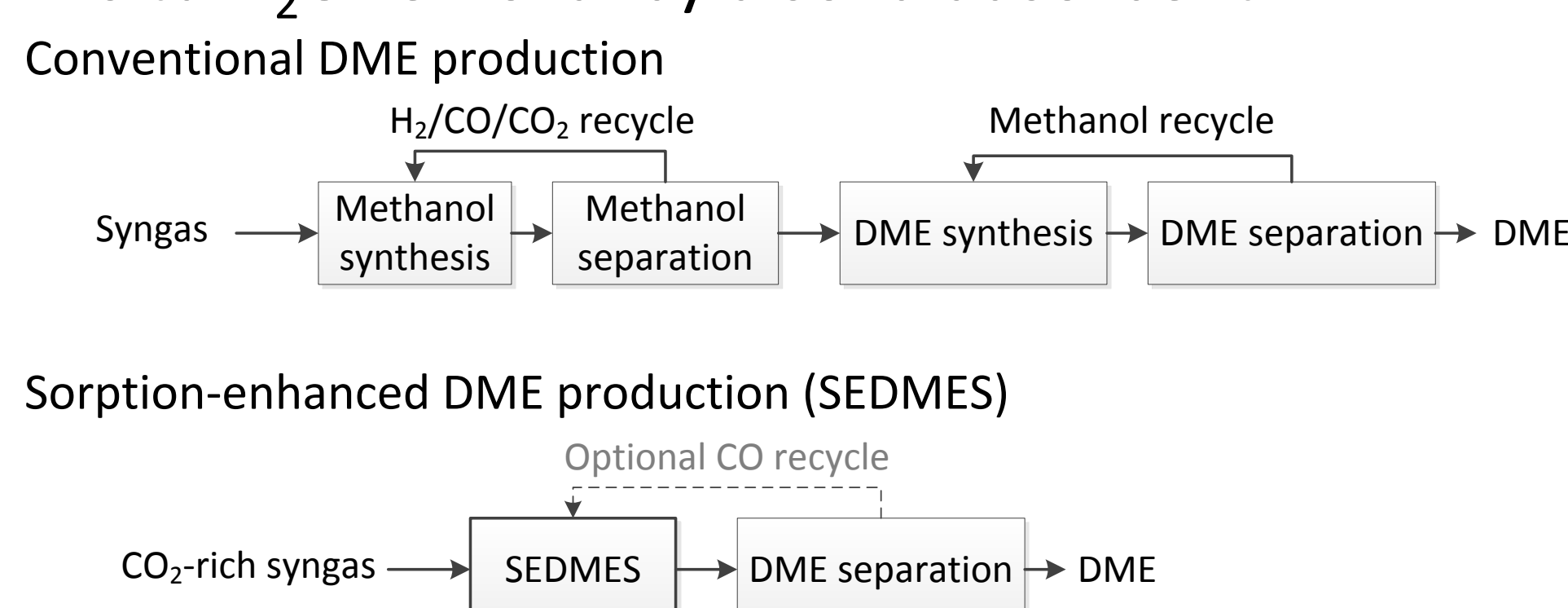
EU Horizon 2020 project FLEDGED combines flexible sorption-enhanced processes to produce dimethyl ether from biomass with an efficient and low cost process.

- 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.
- CO₂ could be utilised directly or via biomass conversion.
- Sustainable hydrogen production from renewable energy sources could be included, supporting Power-to-Product conversion.



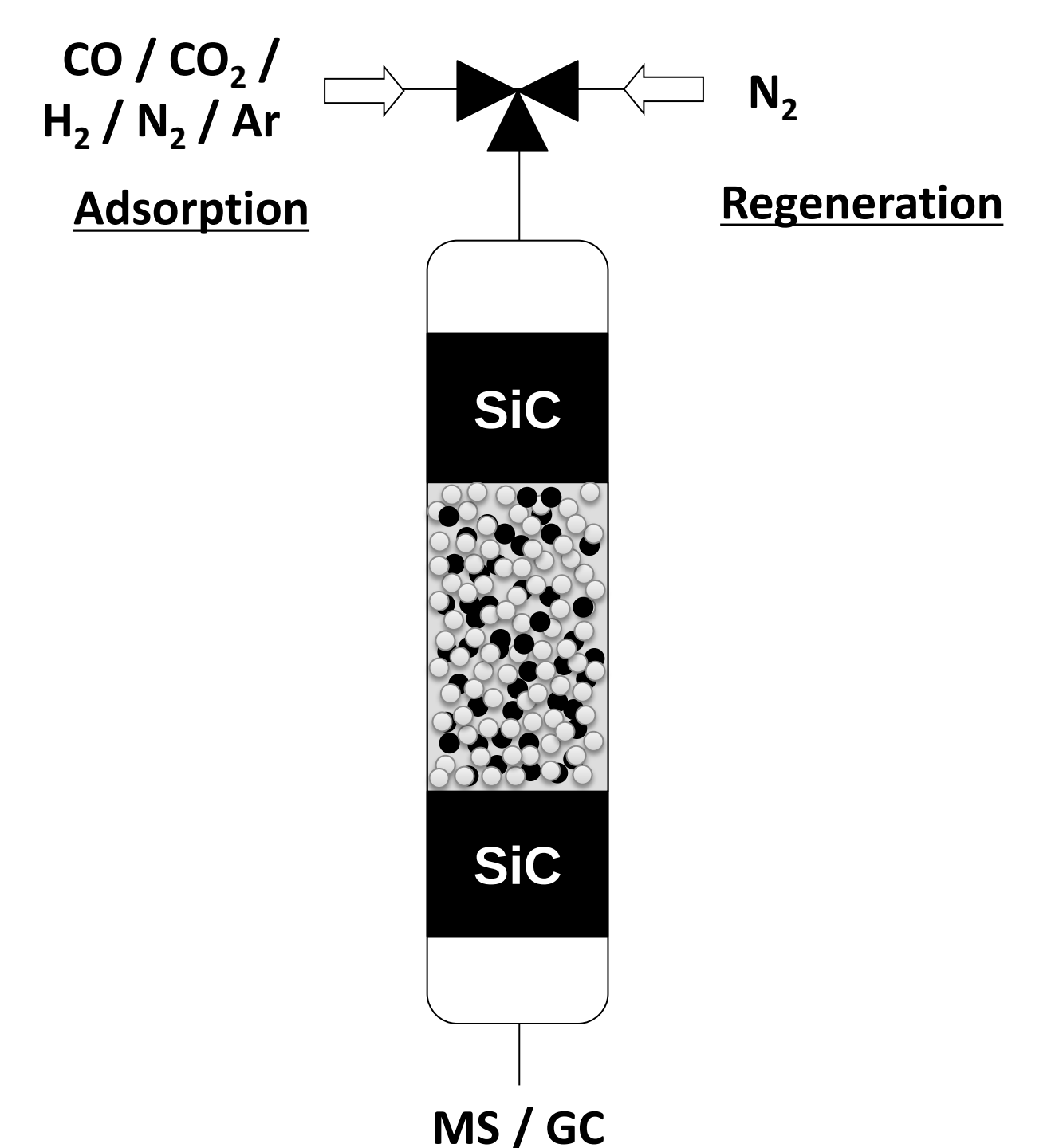
Sorption-enhanced production

- Methanol synthesis: $\text{CO}_2 + 3\text{H}_2 \rightleftharpoons \text{CH}_3\text{OH} + \text{H}_2\text{O}$
- Water-gas shift: $\text{CO} + \text{H}_2\text{O} \rightleftharpoons \text{H}_2 + \text{CO}_2$
- Methanol dehydration: $2\text{CH}_3\text{OH} \rightleftharpoons \text{CH}_3\text{OCH}_3 + \text{H}_2\text{O}$
- SEDMES: In situ H₂O removal by a solid adsorbent.



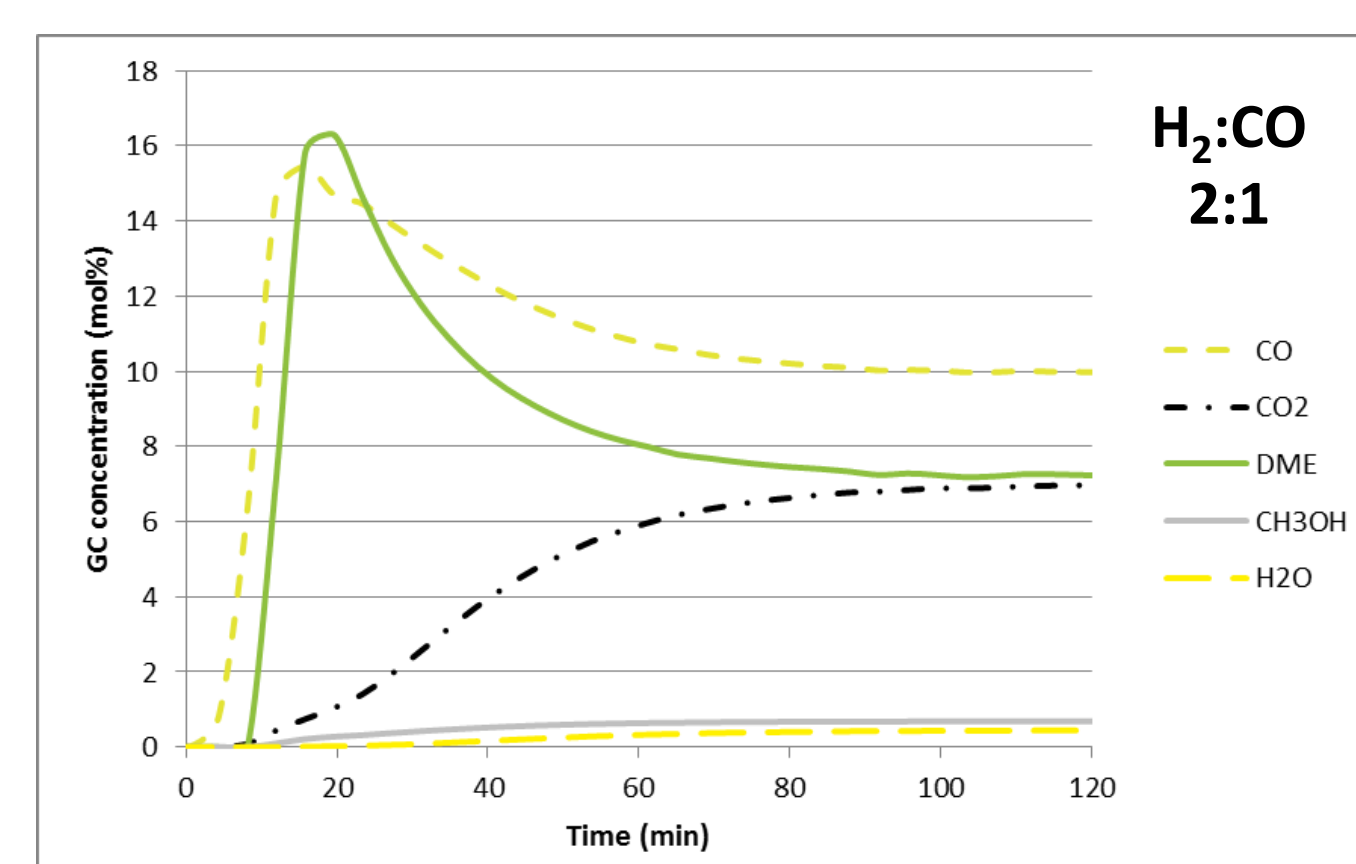
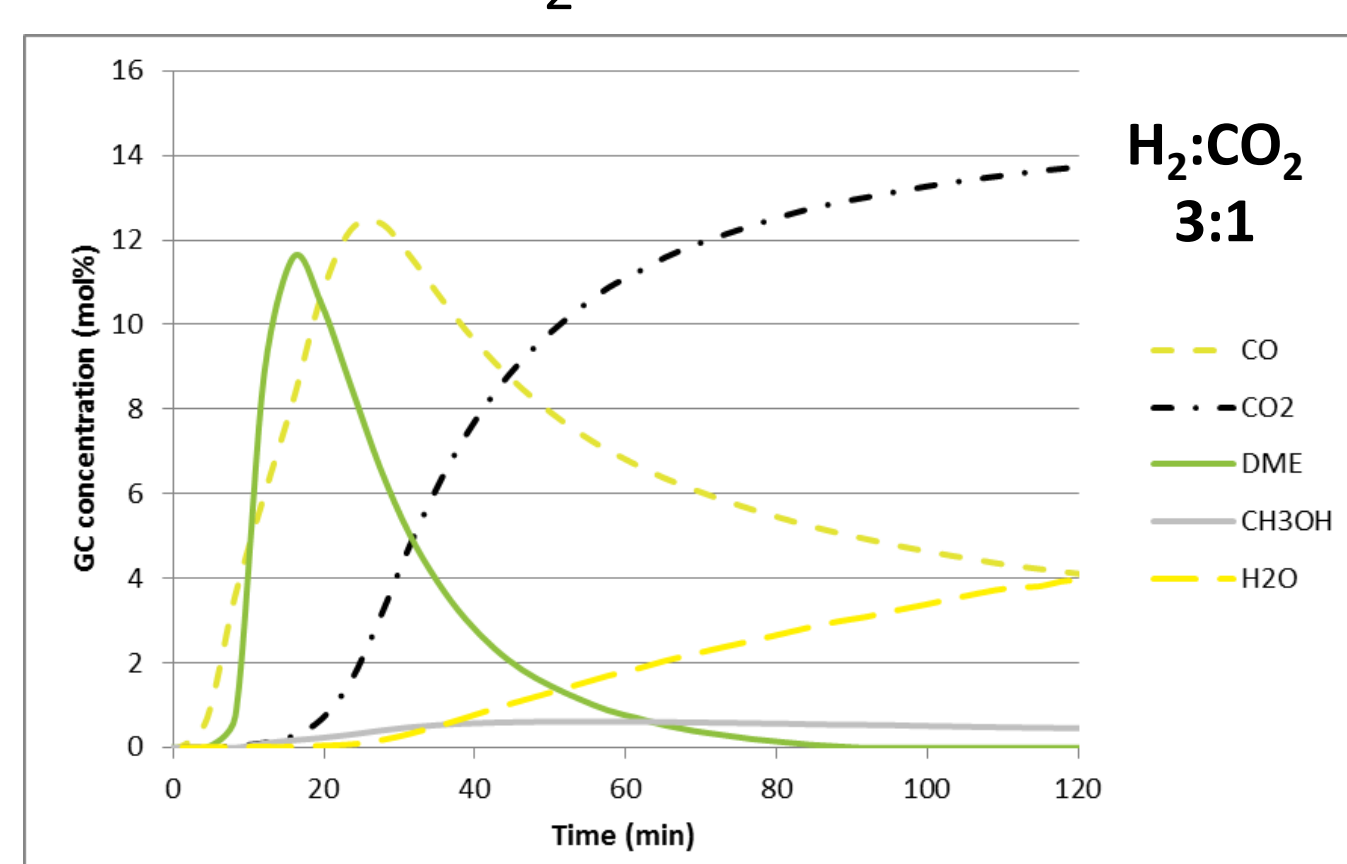
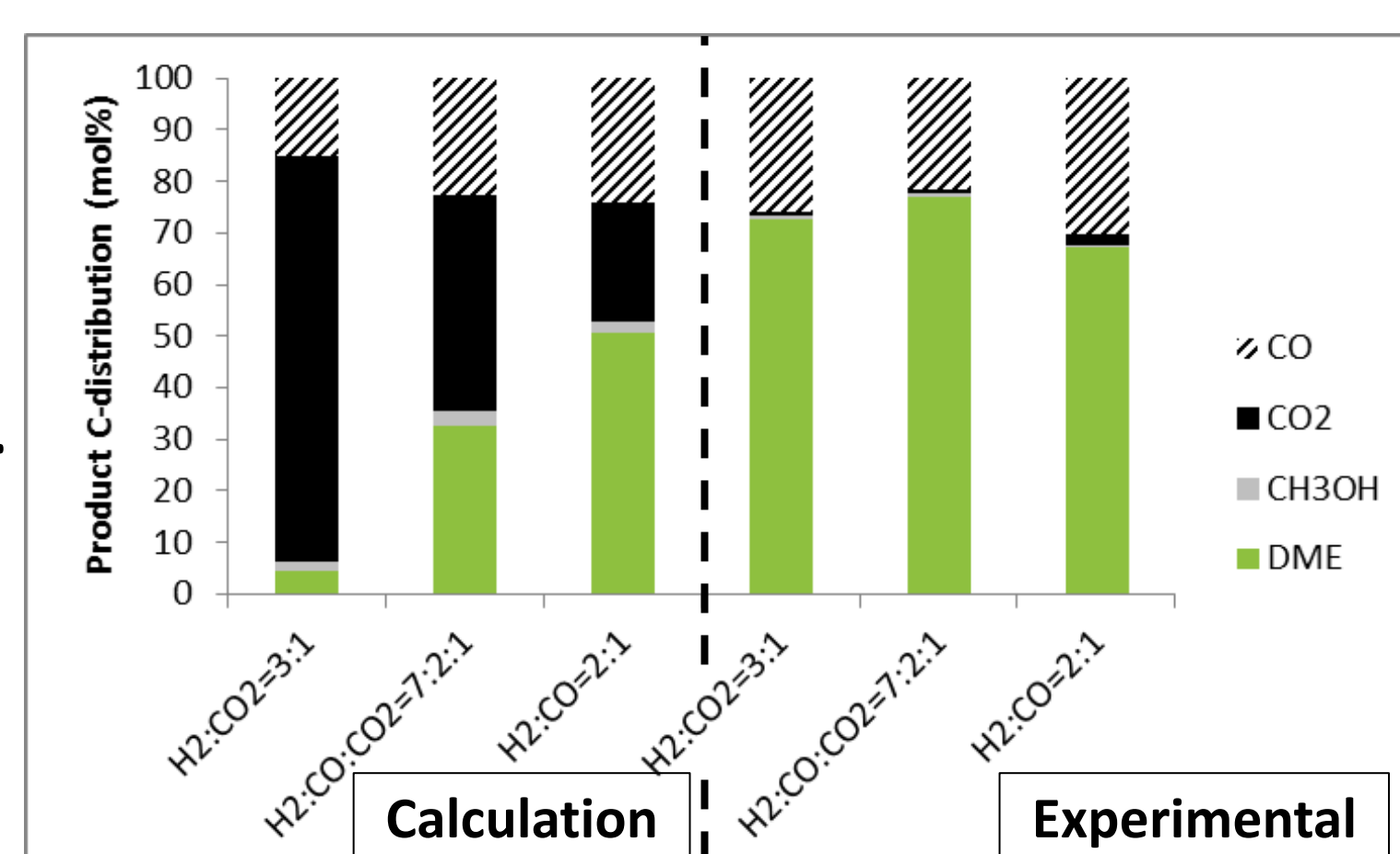
Methods

- 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 CO₂, CO and H₂ in inert N₂ & Ar.
- $M = ([\text{H}_2] - [\text{CO}_2]) / ([\text{CO}] + [\text{CO}_2]) = 2$

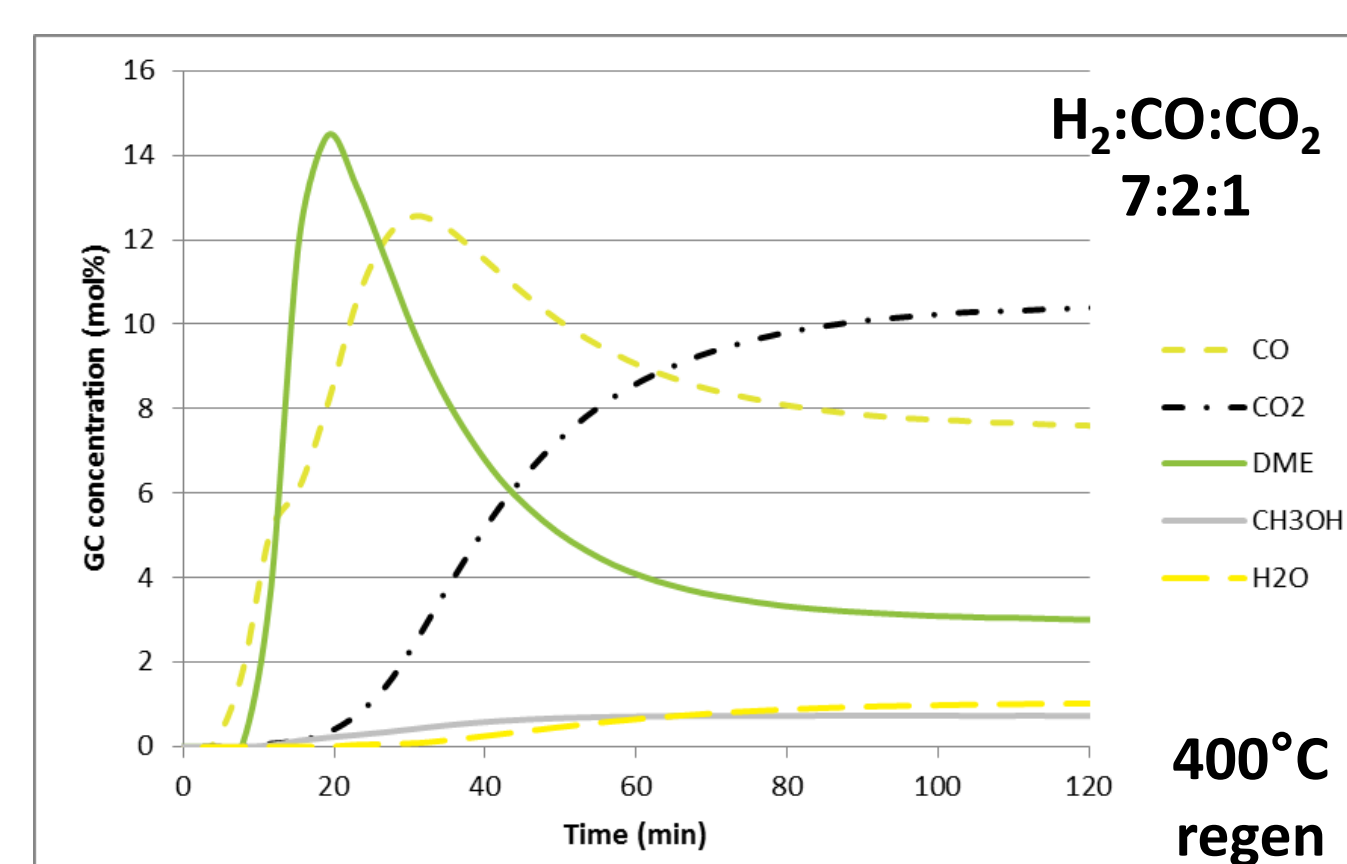
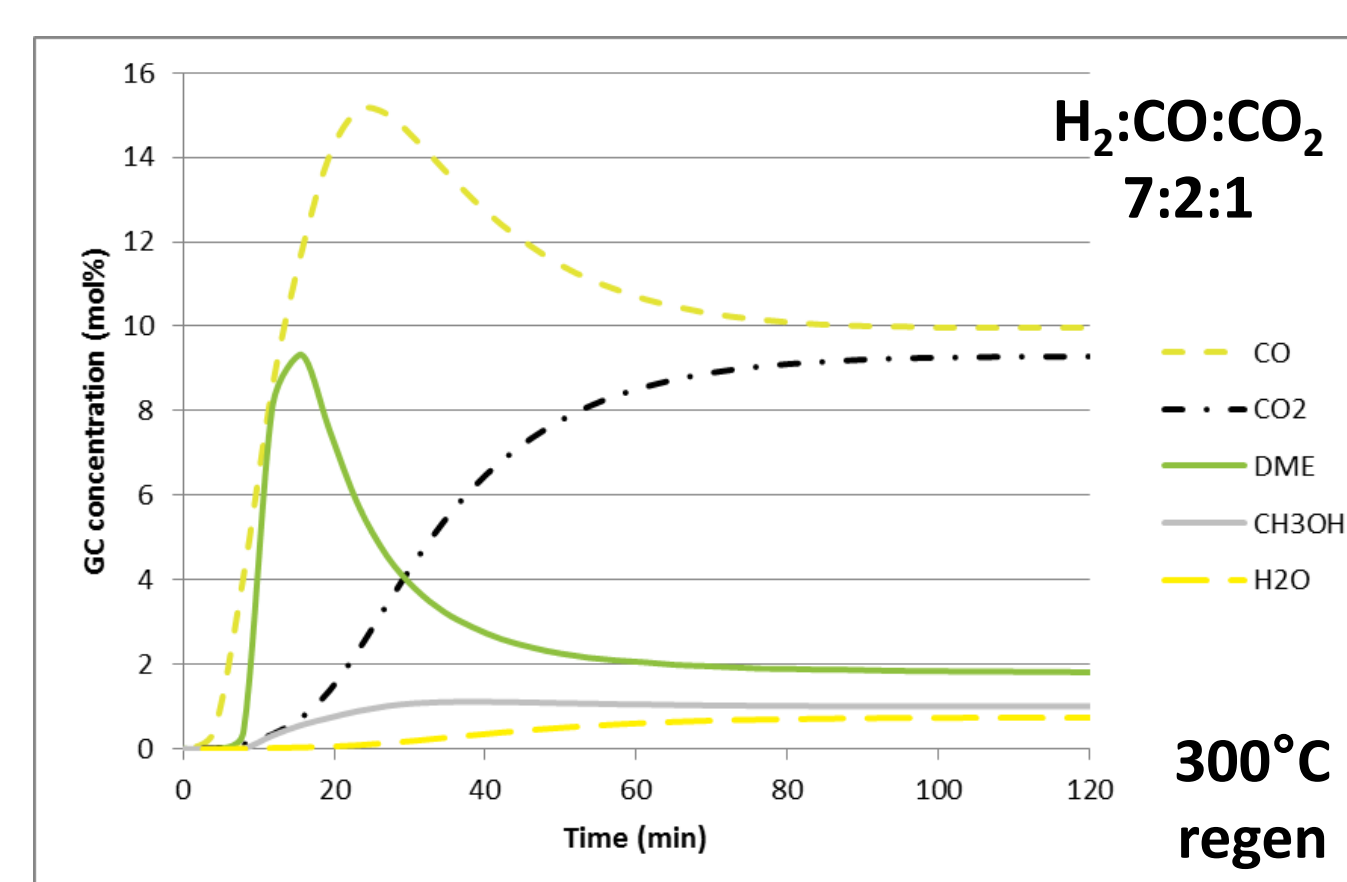


Feed flexibility & Carbon efficiency

- 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 CO₂ reduced to <2%.



Catalyst functionalities



- CZA catalyst active for water-gas shift, methanol synthesis & dehydration.
- Low DME concentration, and CO₂ & 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 CO₂ utilisation (direct or via biomass) possible compared to conventional DME production.
- Multifunctional catalyst and sorbent system is key to performance optimisation.

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