Sorption Enhanced Dimethyl Ether Synthesis (SEDMES)

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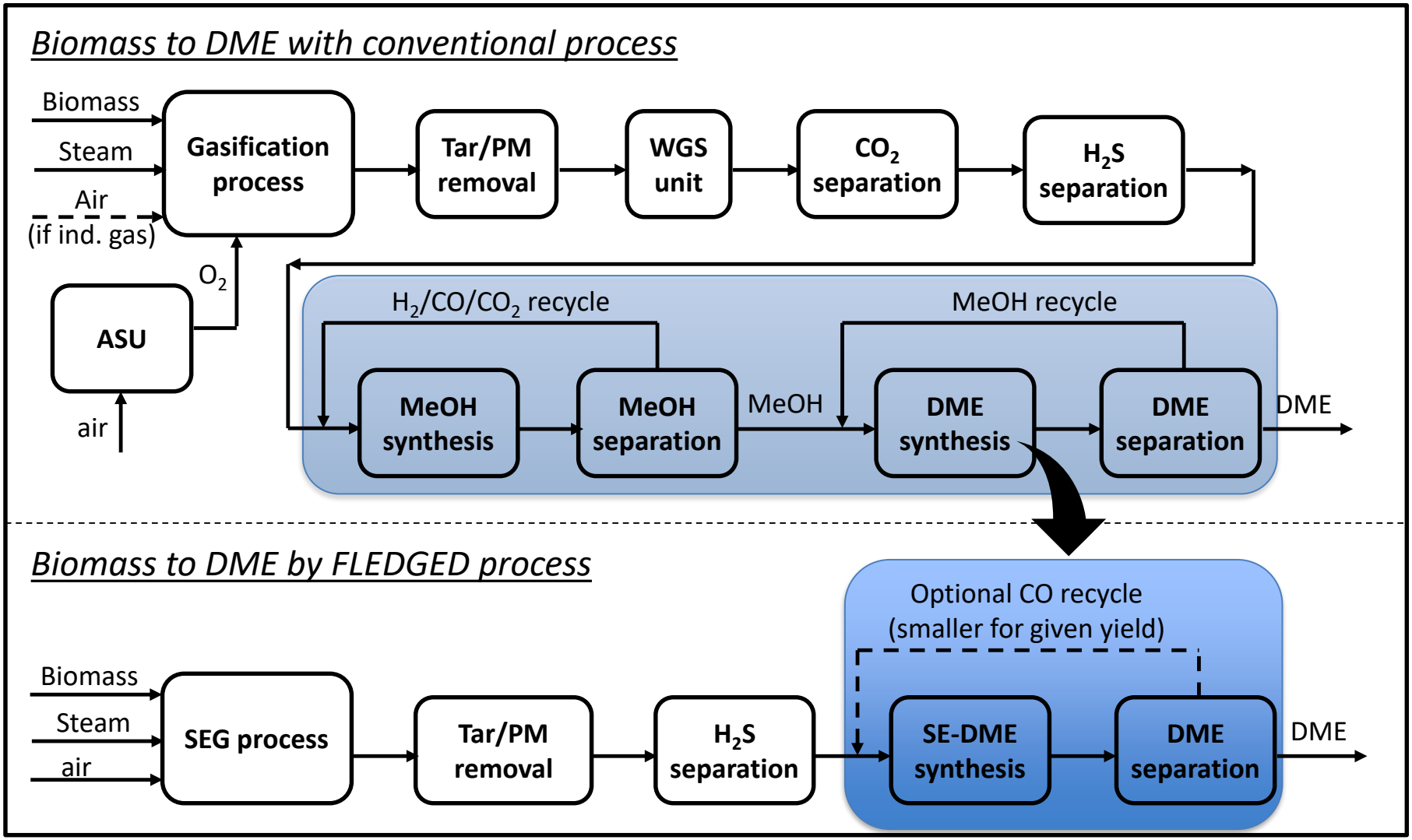
Virtual lab tour

Video of experimental facilities at TNO Petten:

https://www.youtube.com/watch?v=BaTOlbyUM8c&feature=youtu.be

Process intensification: Sorption Enhanced DME Synthesis



Process intensification: Direct DME Synthesis

Feed gas

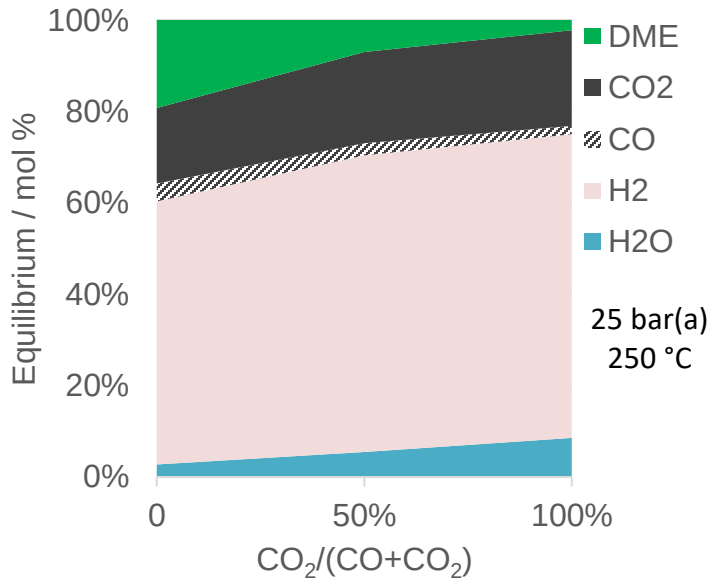
CO and CO_2 with stoichiometric H_2 ($M = \frac{[H_2]-[CO_2]}{[CO]+[CO_2]} = 2$)

Direct DME synthesis equilibrium

$2CO + 4H_2 \rightleftharpoons CH_3OCH_3 + H_2O$ (1)

$2CO_2 + 6H_2 \rightleftharpoons CH_3OCH_3 + 3H_2O$ (2)

$CO_2 + H_2 \rightleftharpoons CO + H_2O$ (3)



- Poor conversion per pass
- High CO_2 concentration product ($CO + H_2O \rightarrow CO_2 + H_2$)

Process intensification: Sorption Enhanced DME Synthesis

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Sorption enhanced DME synthesis

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Henry Louis Le Chatelier (1850 – 1936)

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Sorption enhanced DME synthesis

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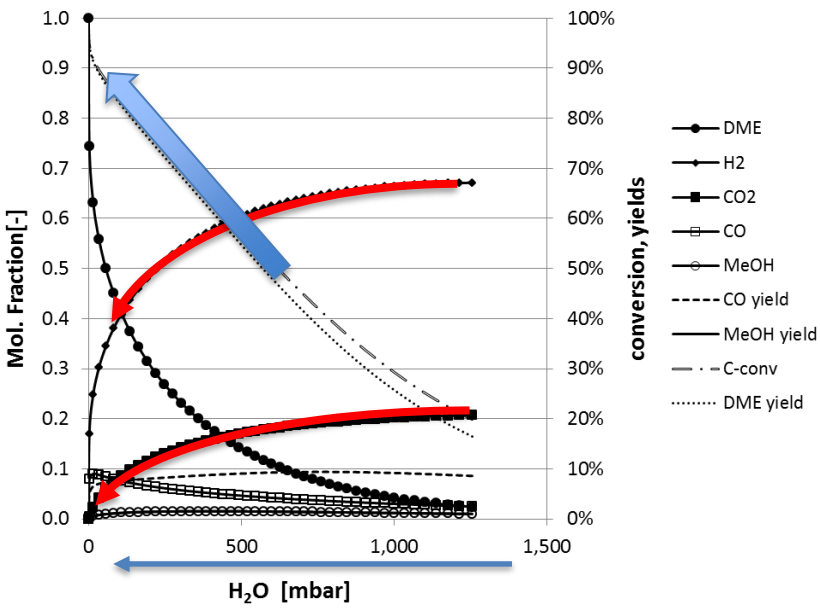

- High conversion per pass
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Process feed flexibility

Direct DME synthesis

275 °C & 40 bar(a), incl. 30% inert

Carbon is found in CO / CO_2 / MeOH / DME

Sorption enhanced DME synthesis

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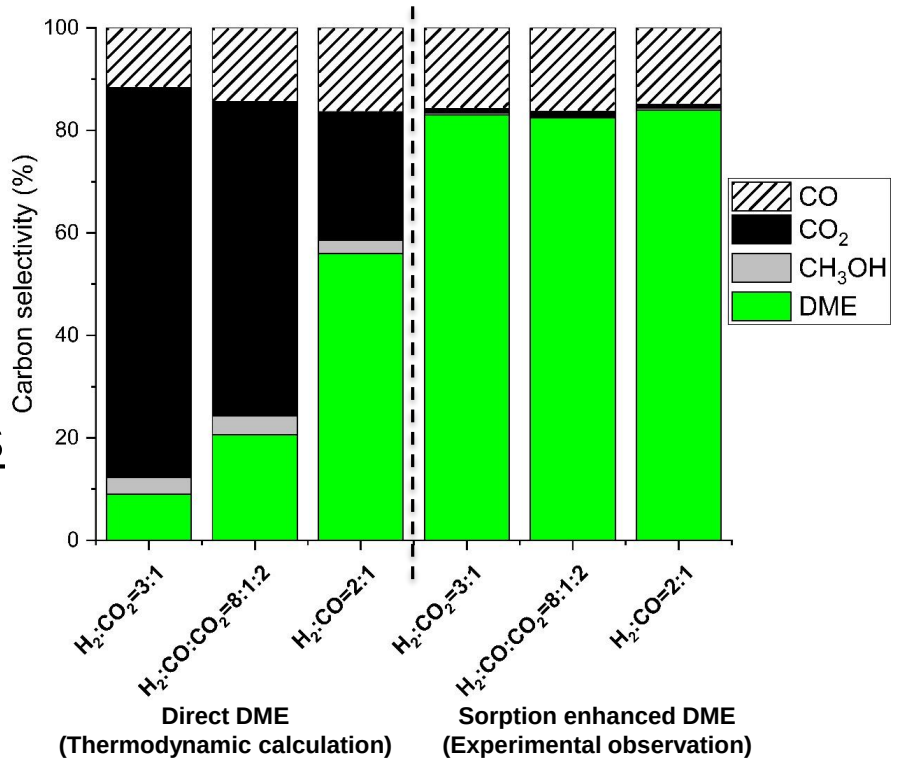
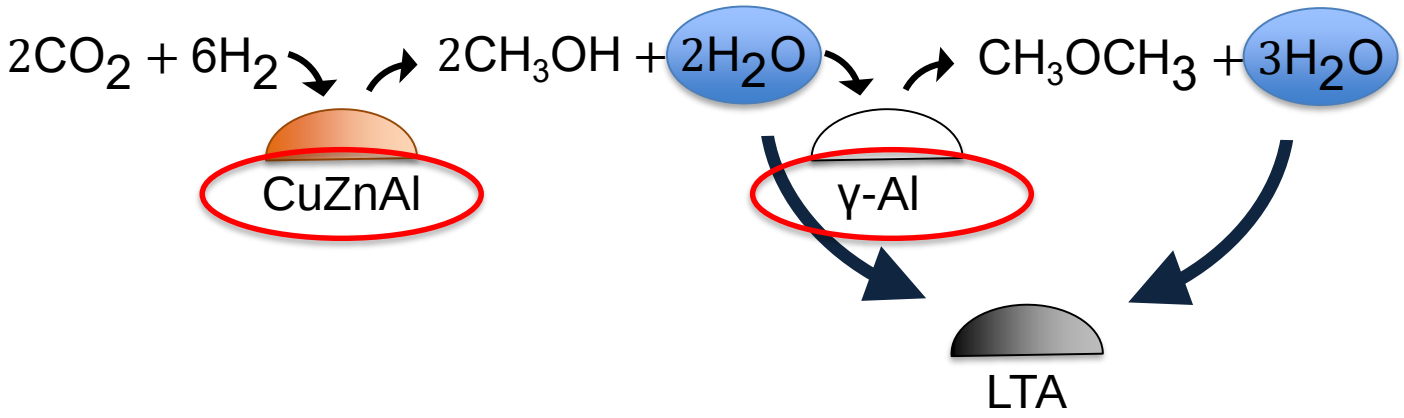


van Kampen et al., Chemical Engineering Journal 374 (2019) 1286–1303.
van Kampen et al., Journal of CO_2 Utilization 37 (2020) 295-308.

SEDMES

In sorption enhanced DME synthesis, SEDMES, the equilibrium of direct DME synthesis is shifted by using a physical adsorbent



Liuzzi et al., Sustainable Energy & Fuels (2020).
Boon et al. Catalysis Communications 119 (2019) 22-27.
van Kampen et al., Adsorption (2020).

SEDMES: scale-up

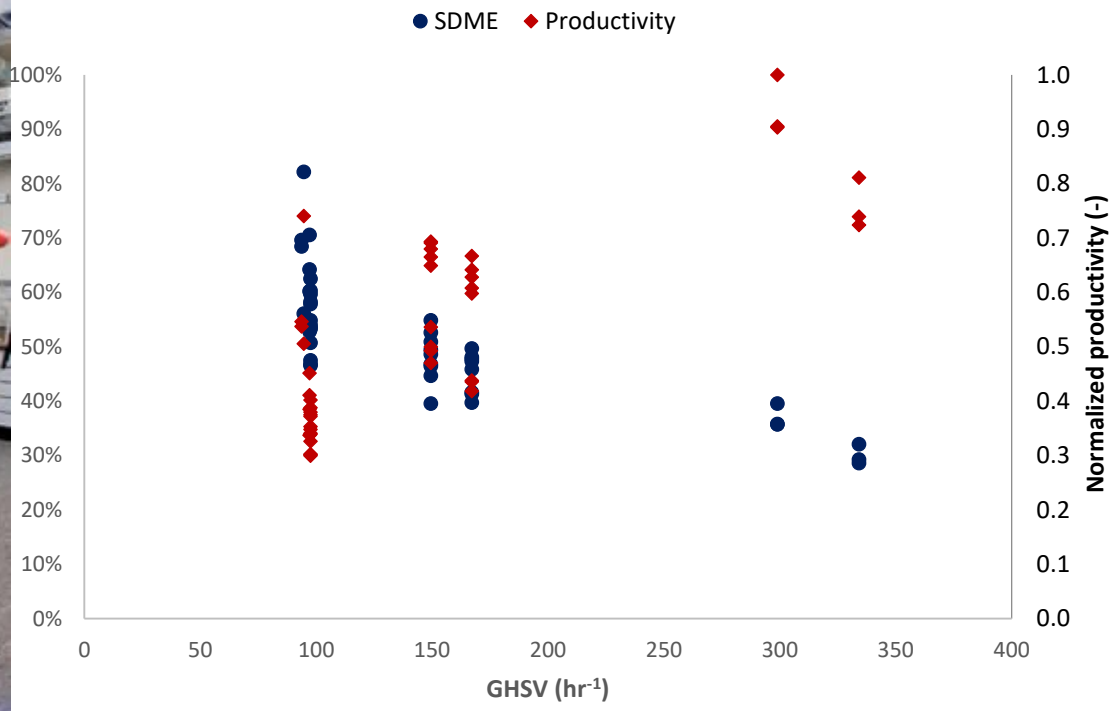
SPIDER

CATE

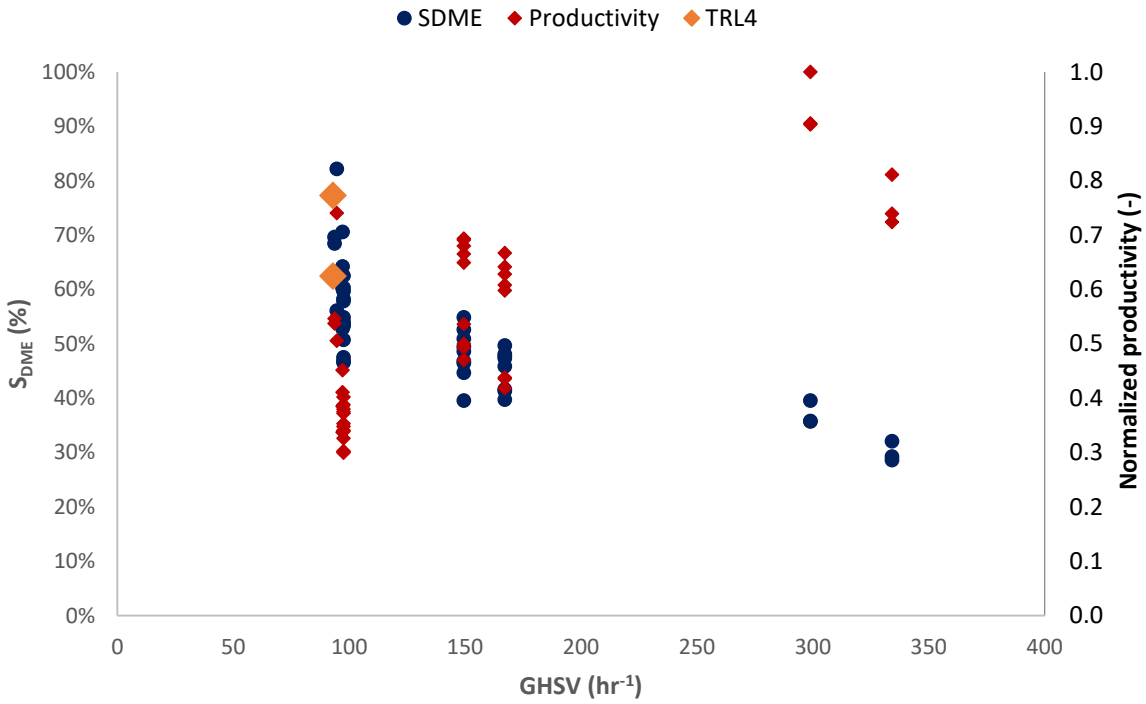
SEWGS-1

SEWGS-7

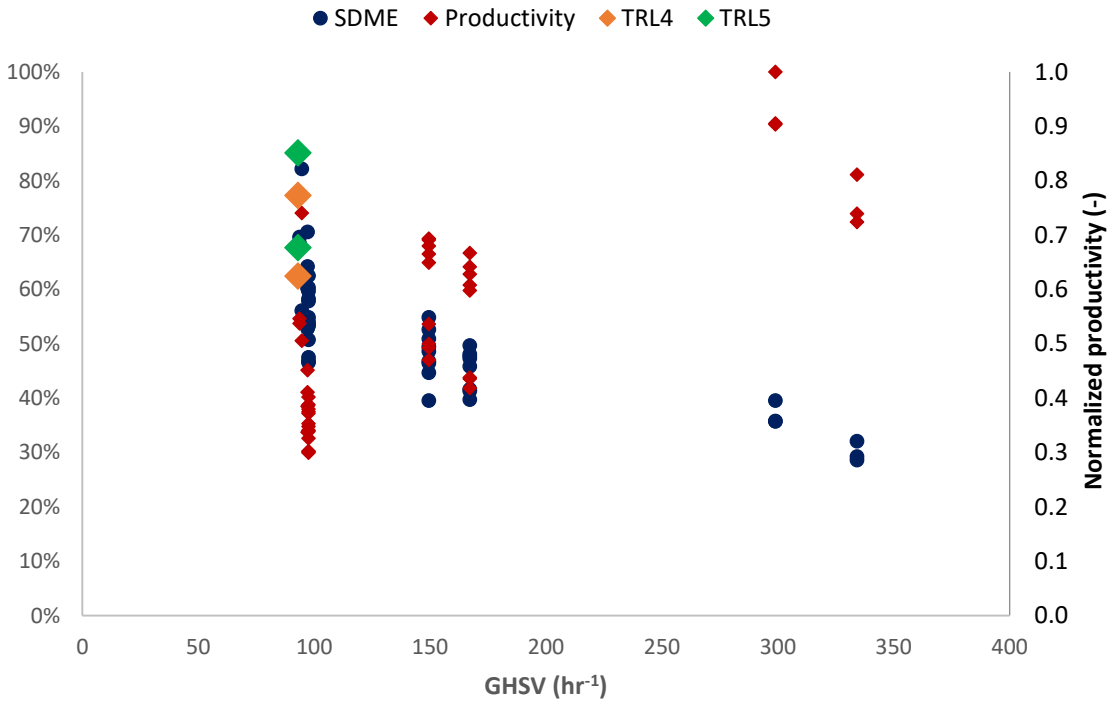
SEDMES: Experimental validation



SEDMES: Experimental validation



SEDMES: Experimental validation



SEDMES: industrially relevant demonstration (TRL5)

Experimental campaign over 3 months period (April – July 2020)

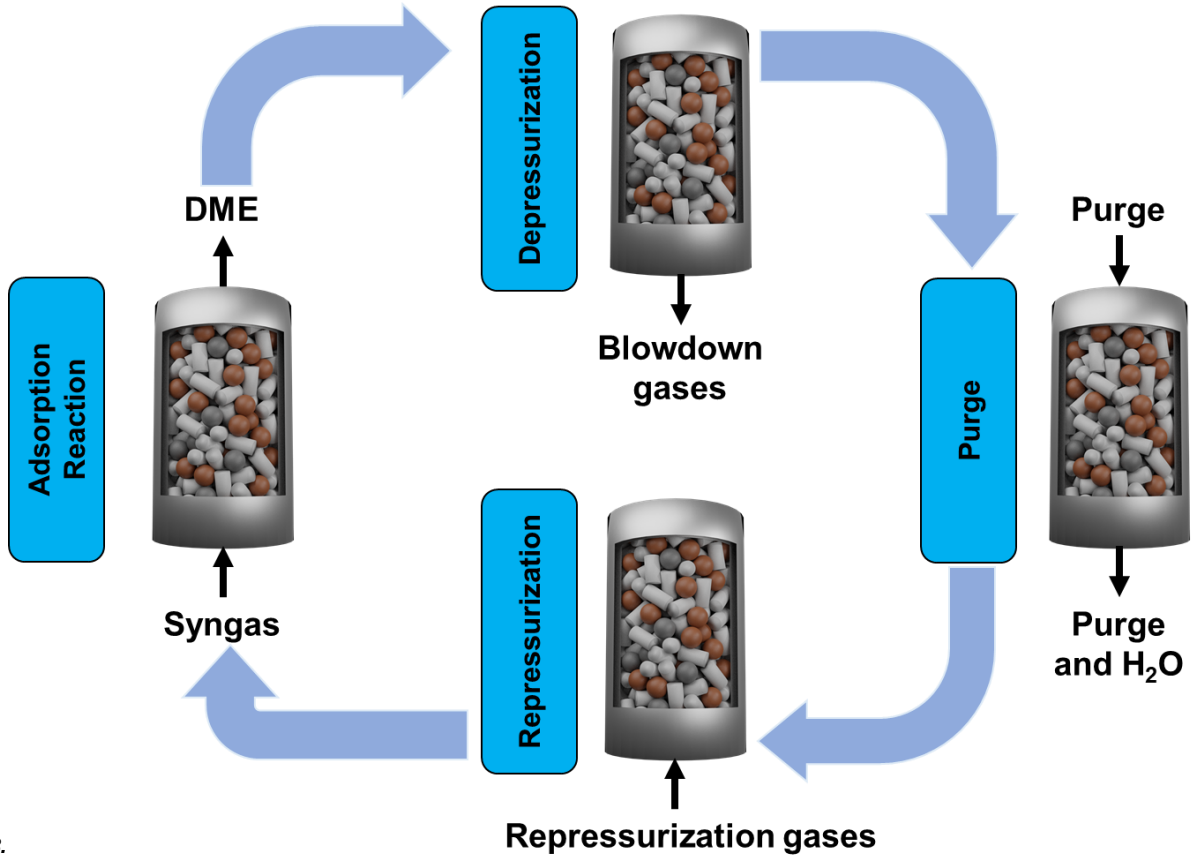
Multi-column test rig

- 6 reactors of 6 m
- Full cycle demonstration
- Duration testing
  - 500-1000 cycles
- High single-pass conversion of CO_2 to DME
  - Up to 95% DME carbon selectivity
- PSA regeneration confirmed
  - Allowing for increased productivity
- Heat effects manageable

SEDMES: Cycle design

- SEDMES
- Cyclic reactor model
- Validated at TRL4

Pressure Swing Adsorption (PSA) cycle



van Kampen et al., Journal of CO_2 Utilization 37 (2020) 295-308.
van Kampen et al., Chemical Communications (2020).
Guffanti et al., Chemical Engineering Journal (2021).

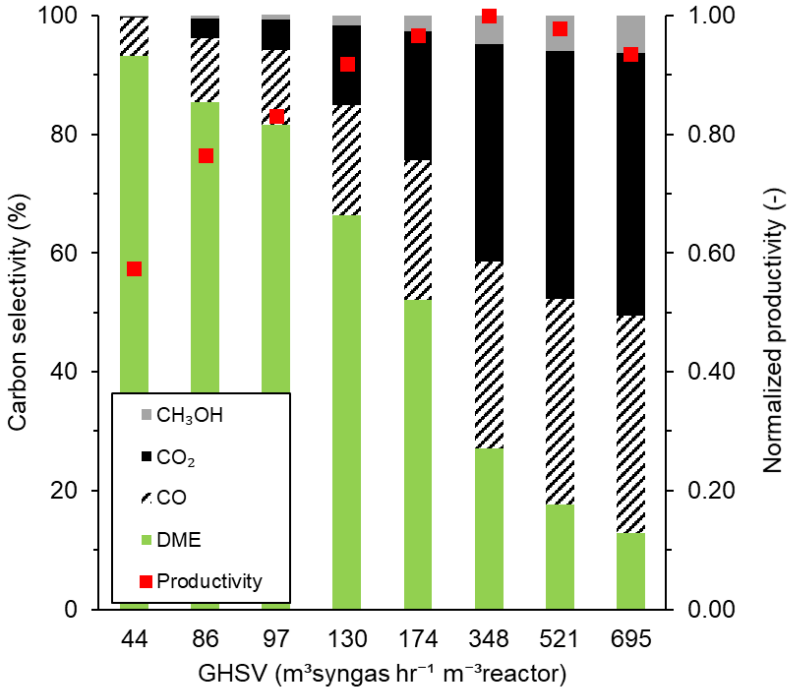
SEDMES: Cycle design

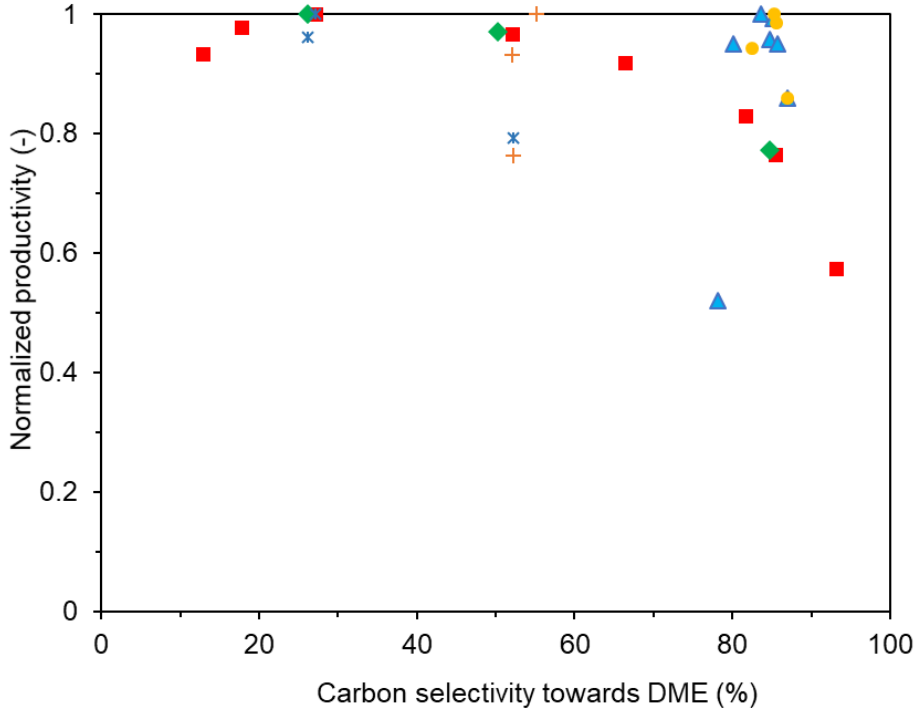
Column 1	ADS	PEQDN	BD	PURGE	PEQUP	REP
Column 2	REP	ADS	PEQDN	BD	PURGE	PEQUP
Column 3	PEQUP	REP	ADS	PEQDN	BD	PURGE
Column 4	PURGE	PEQUP	REP	ADS	PEQDN	BD
Column 5	BD	PURGE	PEQUP	REP	ADS	PEQDN
Column 6	PEQDN	BD	PURGE	PEQUP	REP	ADS

Optimisation parameters:

- Gas hourly space velocity during adsorption, purge and repressurisation step
- Cycle time
- Pressure equalisation step(s)
- Gas recycling
- Operating conditions per step
- Adjusting boundary conditions

SEDMES: Cycle design





Typical for sorption enhanced processes trade-off between carbon selectivity towards DME and productivity

SEDMES: Conclusions

- Separation enhanced synthesis technology offers intensified processes for economic valorisation of CO_2-rich syngas
- Sorption enhanced DME synthesis, SEDMES, has been developed using commercially available materials
- Validated modelling frameworks have allowed to design the SEDMES reactor and optimise the SEDMES process for Fledged case
- SEDMES technology validated in industrially relevant multi-column, environment (TRL5)

Contact information

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