

Waste-2-H₂ – Syngas to methanol

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Catalytic Processes of Fuel Conversion



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- **Catalysis for synthesis processes** (e.g. CH_4 - and CH_3OH -synthesis)
 - reaction kinetics and reaction mechanisms
 - catalyst deactivation
 - heat and mass transfer
- **Process development**
 - three phase reactors (bubble column, trickle bed,...)
 - (metallic) honeycomb reactors
 - utilization of CO_2 as carbon source
 - modelling of dynamic processes

Motivation

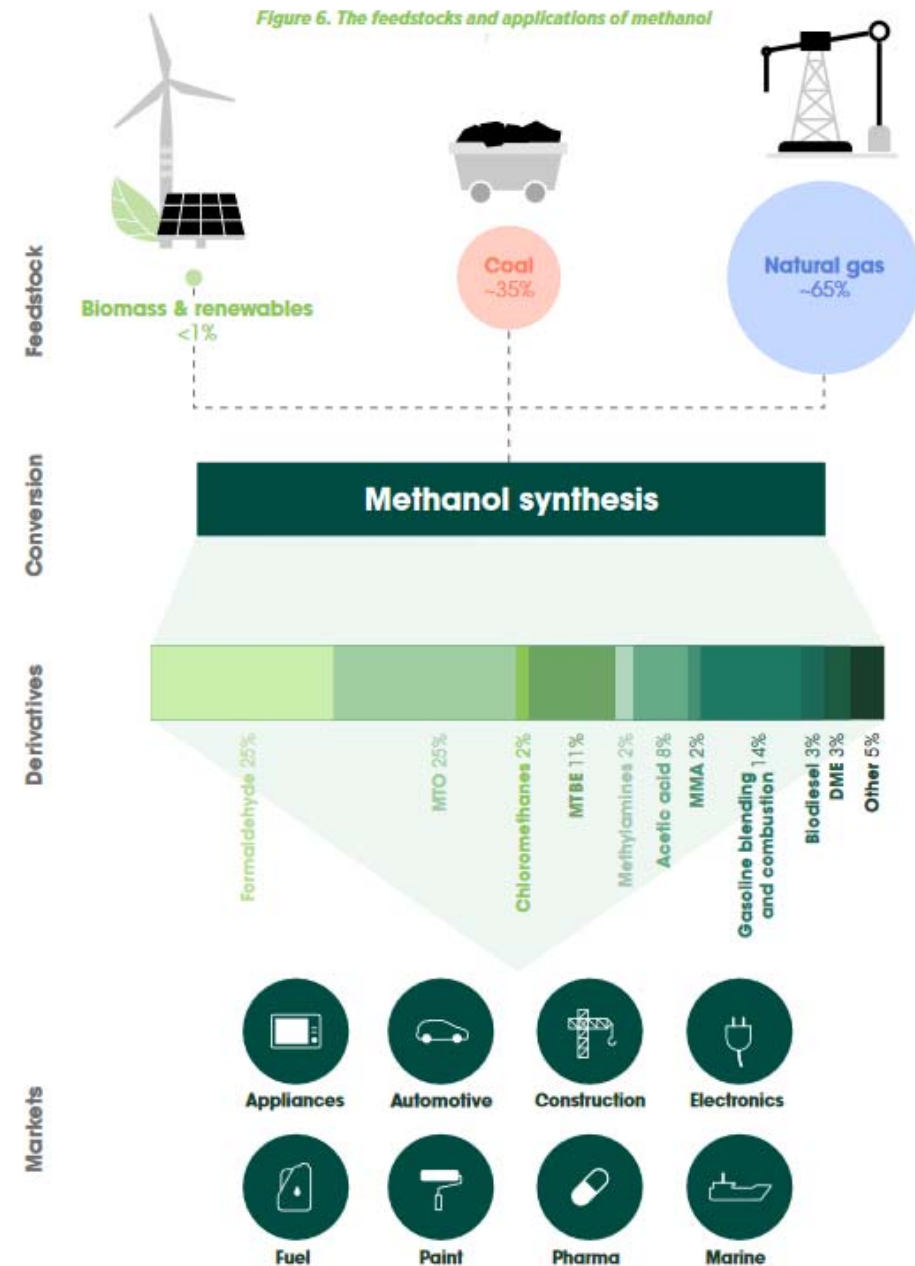
- Important feedstock for chemical industry (69 %) and energy source (31 %)
- Global production of methanol nearly doubled over the last decade
- The production of 98 Mt methanol in 2019 contributed about 10 % to the total chemical and petrochemical sector's CO₂ emissions.



Renewable methanol as a key component for a circular economy by providing a „green“ ...

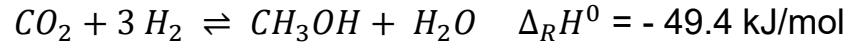
1. feedstock for the chemical industry
2. energy carrier with a high energy density

Source: IRENA AND METHANOL INSTITUTE (2021), Innovation Outlook : Renewable Methanol, International Renewable Energy Agency, Abu Dhabi..



Basics on Methanol Synthesis

Reaction:

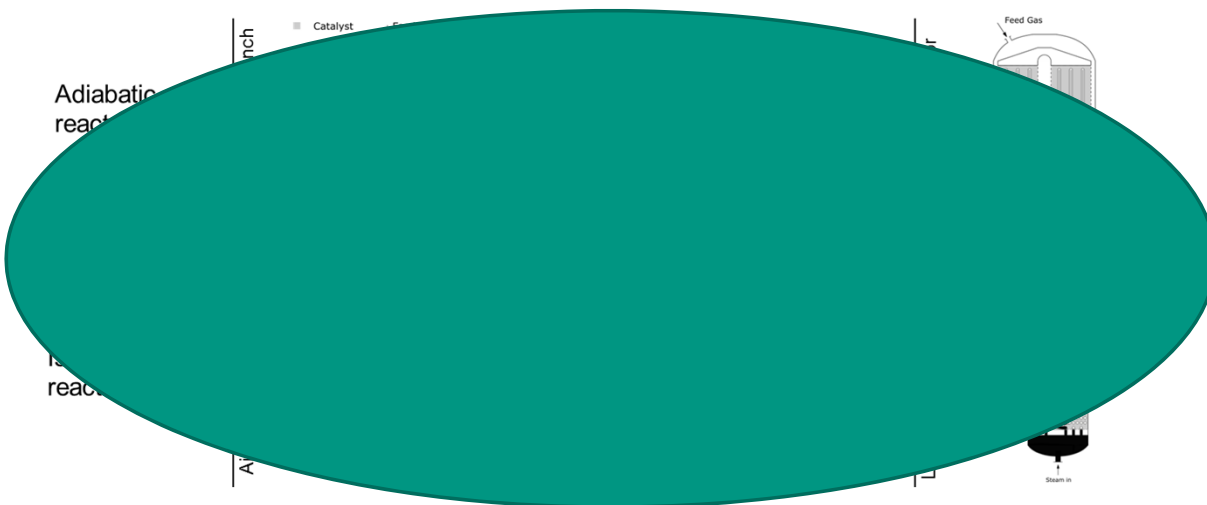


Catalyst: Cu/ZnO/Al₂O₃ (modified)

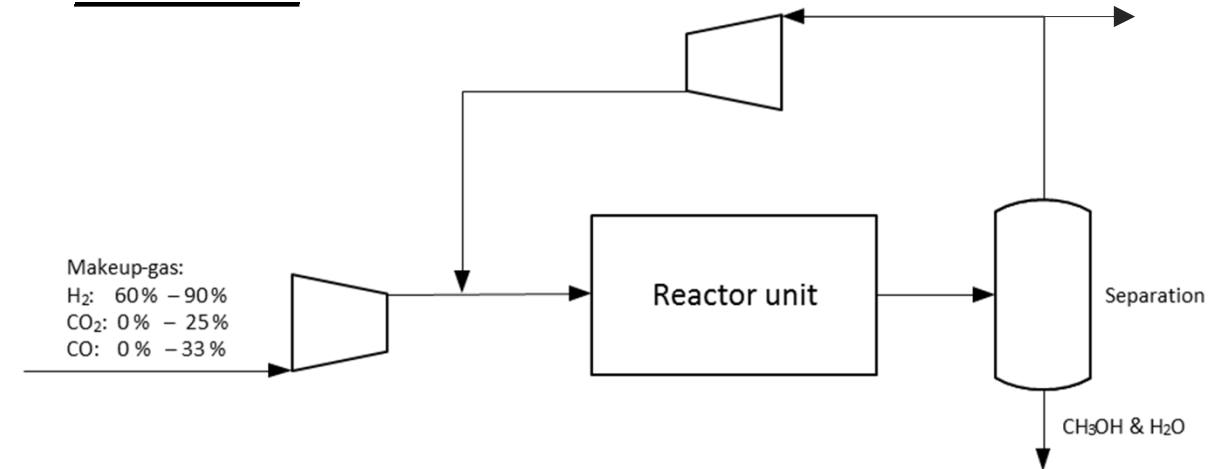
Temperature: 220 °C – 280 °C

Pressure: 60 bar – 100 bar

Reactors:



Process:



Research challenges:

Established methanol synthesis (CO₂/CO_x < 10 mol-%):

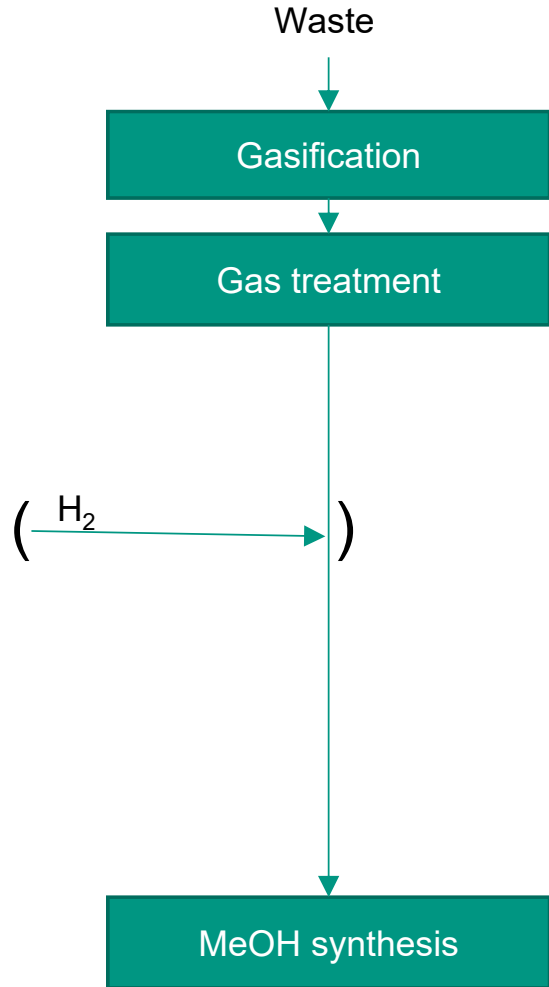
- Efficient heat removal (thermal deactivation of catalyst)
- Product inhibition (in-situ / interstage removal)
- Understanding the reaction mechanisms to develop new catalysts
- Process-modelling

Methanol from CO₂:

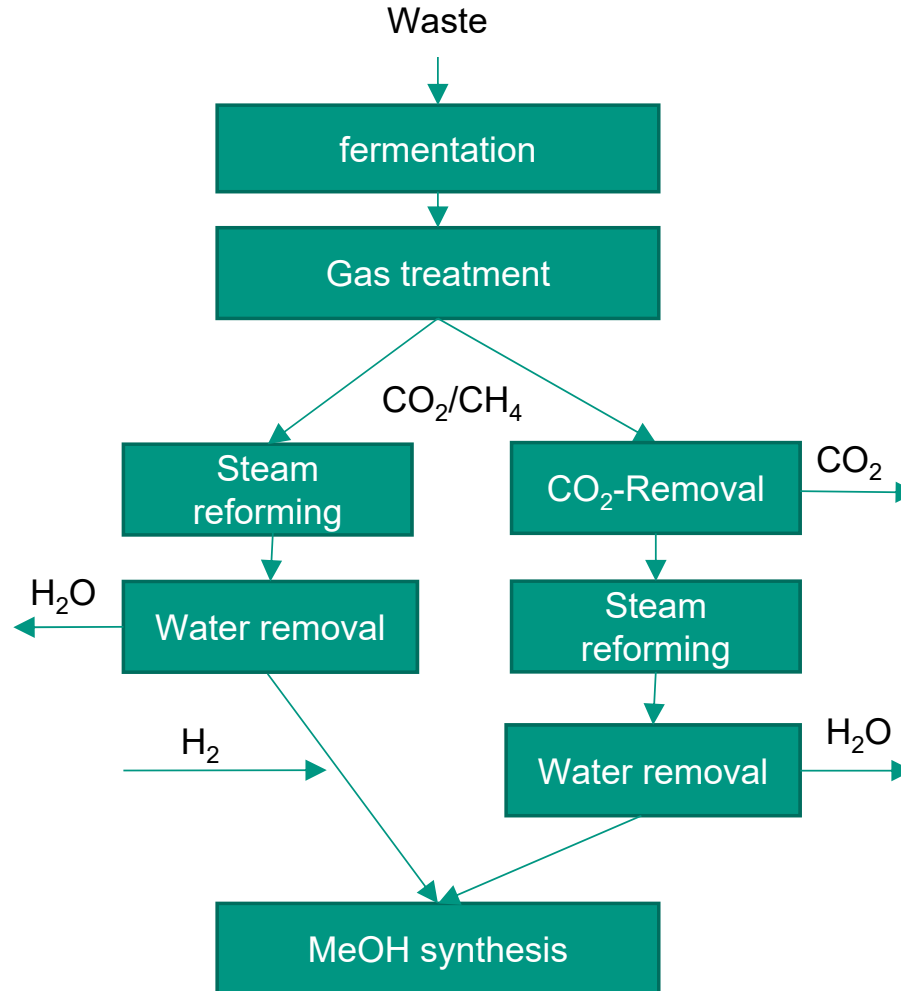
- Low rate of reaction (catalyst development)
- Product deactivation (H₂O)
- Profitable small scale application
- Dynamic operation

Waste-2-Syngas-2-MeOH Options

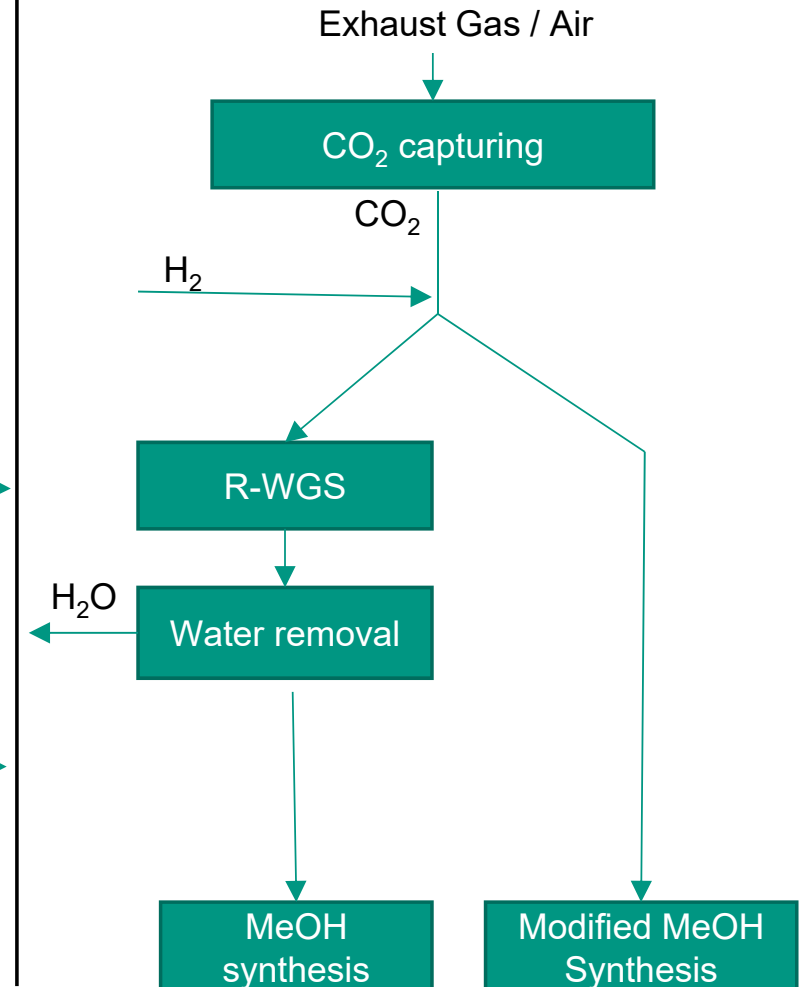
Gasification



Biogas-reforming

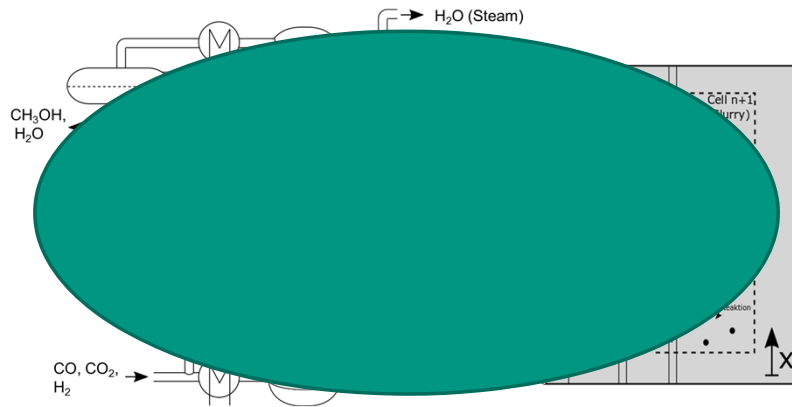


CCU + H₂



Methanol research at KIT-EBI-ceb

3-Phase-MeOH-Synthesis (Process development):



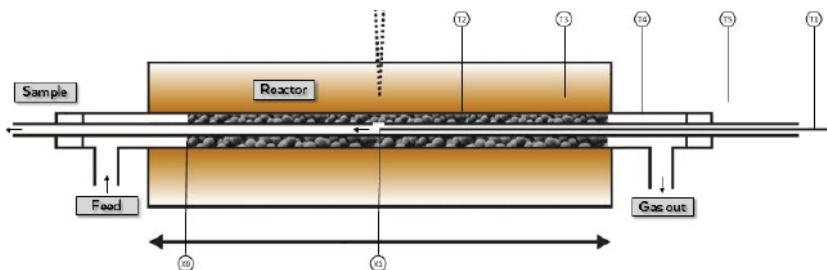
Slurry bubble column reactor

- Efficient heat removal with heat transfer fluid
- High heat capacity of heat transfer fluid stabilizes thermal behavior in dynamic operation mode

Core challenge:

- Mathematical description, reactor design & upscaling

Investigation of reaction kinetics and deactivation:



Work in progress

Profile reactor

- Measurement of concentration and temperature profiles inside the catalyst bed
- Simulating recycle conditions with MeOH and H2O in feed

Core challenge:

- Understanding catalyst deactivation in 2- and 3-Phase-MeOH-Synthesis

Source: Reacsotics Compact Profile Reactor (CPR) Betriebsanleitung

Thank you for your attention!



Die Neubauten 40.50 und 40.51, Photo: Stephan Baumann

