CO_2 conversion to light olefins

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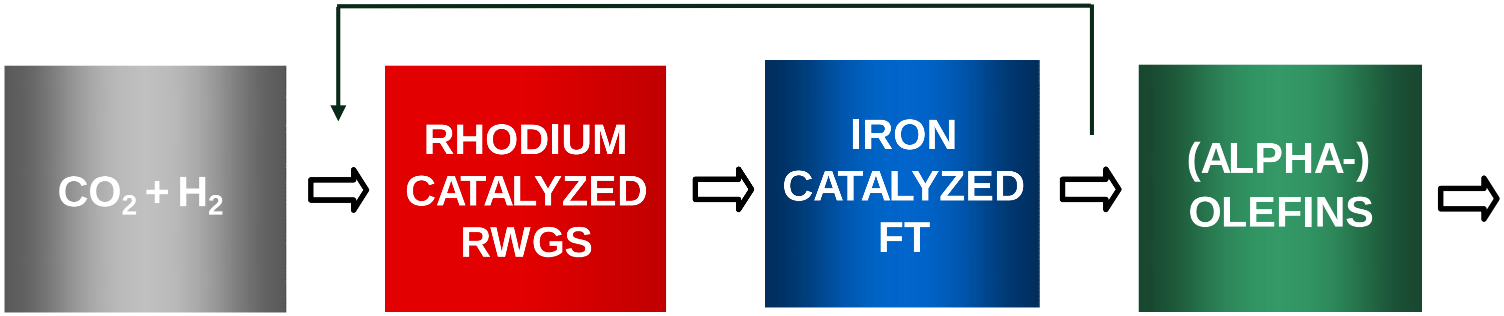
Two step process from CO_2 to light olefins



- Step 1: Reverse Water Gas Shift (RWGS)

  $CO_2 + H_2 \rightarrow$ Synthesis gas ($CO + H_2$) and water

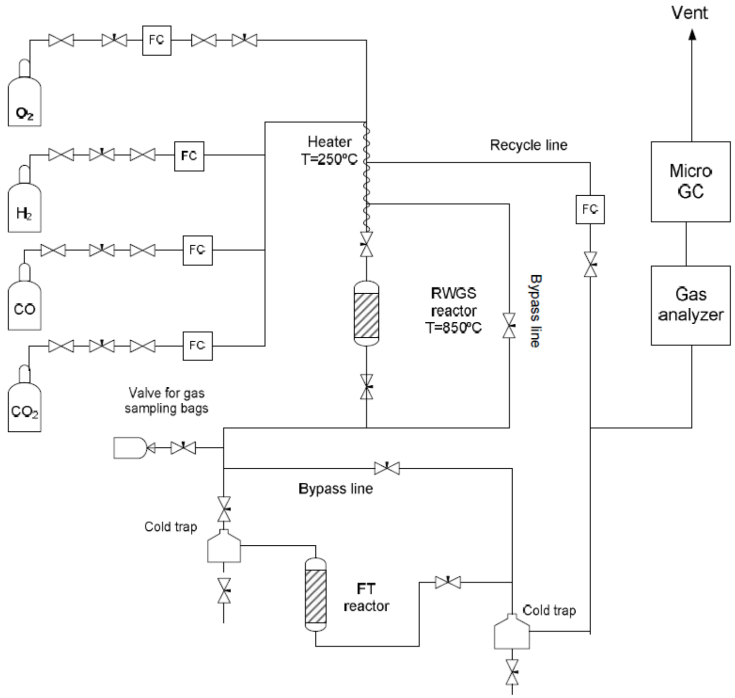
- Step 2: Fischer Tropsch synthesis (FT)

  $CO + 2H_2 \rightarrow$ Hydrocarbons

- FT process conditions determine the quality of the hydrocarbons
  - High temperature and low pressure to yield lighter products

Experimental setup & Research plan

- RWGS and FT reactors in series
  - Rh/Al2O3 washcoated catalyst in RWGS
  - Packed-bed FT reactor in fluidized sand bath
- Objective of the research to test different process conditions and FT catalysts to find the optimal conditions for light olefin production from CO_2



FTO catalysts prepared and tested

1. Fe-Mn-Cu/SiO2
2. Fe-Pb/SiO2
3. Fe-Na-S/AC
4. Co-Ru/TiO2
5. Fe-Na-S/Al2O3
6. Fe-Mn/Al2O3

- Desired properties
  - High selectivity to lower olefins
  - Low selectivity to methane
  - High CO conversion
  - Stability

Experiments with the catalysts

- Experiments with different process conditions and with gas recycling
    - H_2/CO_2 feed ratio
    - volumetric flow rate (Q)
    - FT reaction temperature
    - amount of recycled gas
- Cobalt-based catalyst in temperatures of 210-240°C

Without gas recycling

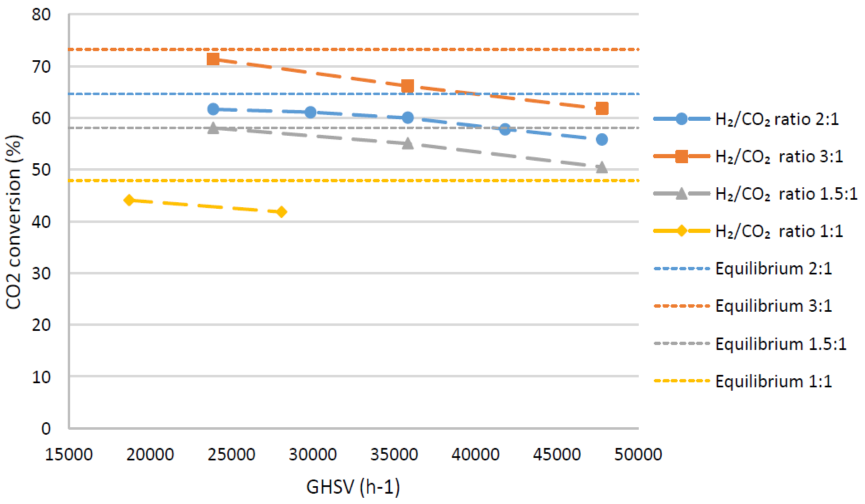
RWGS			FT
Temperature (°C)	H2/CO2 feed ratio	Q (l/min)	**Temperature (°C)**
850	2,0	0,75-1,25	**320-350**
850	1,0	0,5-1,25	**320-350**

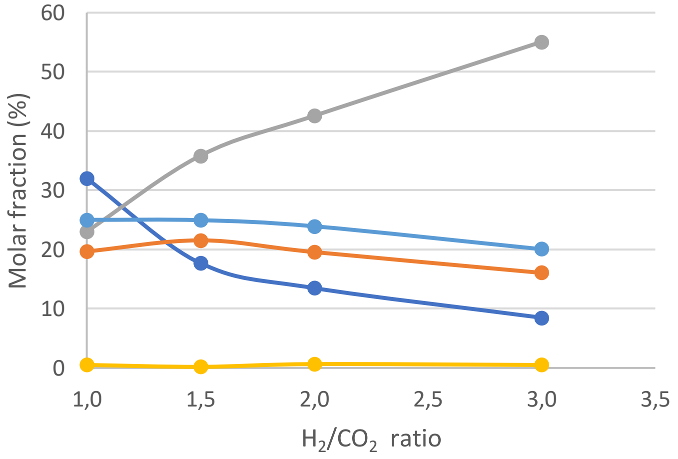
With gas recycling

RWGS			FT	
Temperature (°C)	H2/CO2 feed ratio	Q (l/min)	Temperature (°C)	**Gas recycling Q (l/min)**
850	2,0	0,5-1,25	340	**0,15-0,45**
850	1,0	0,5-1,25	340	**0,15-0,45**

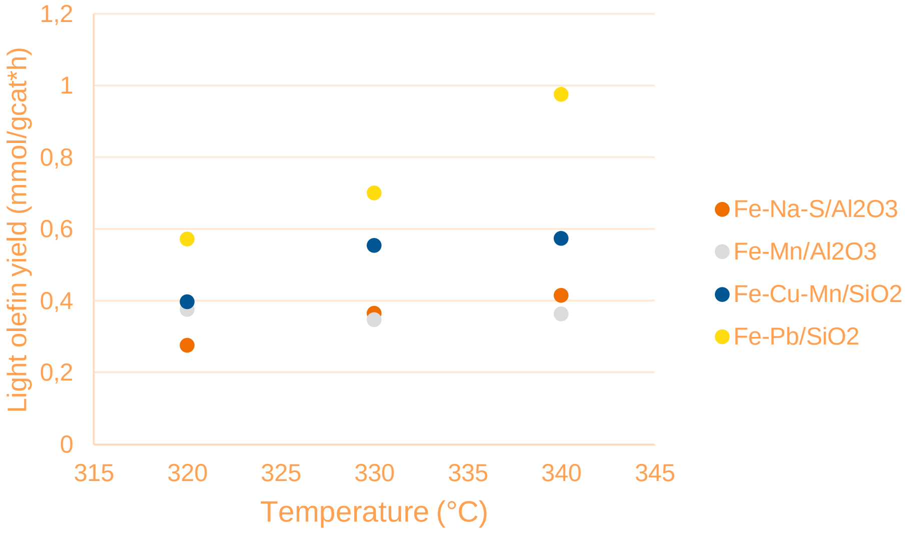
RWGS results

- Conversions close to equilibrium
- Good quality syngas
- Methane selectivity 2-10 %
  - Dependent on H_2/CO_2 ratio
- No catalyst deactivation
- No carbon deposition



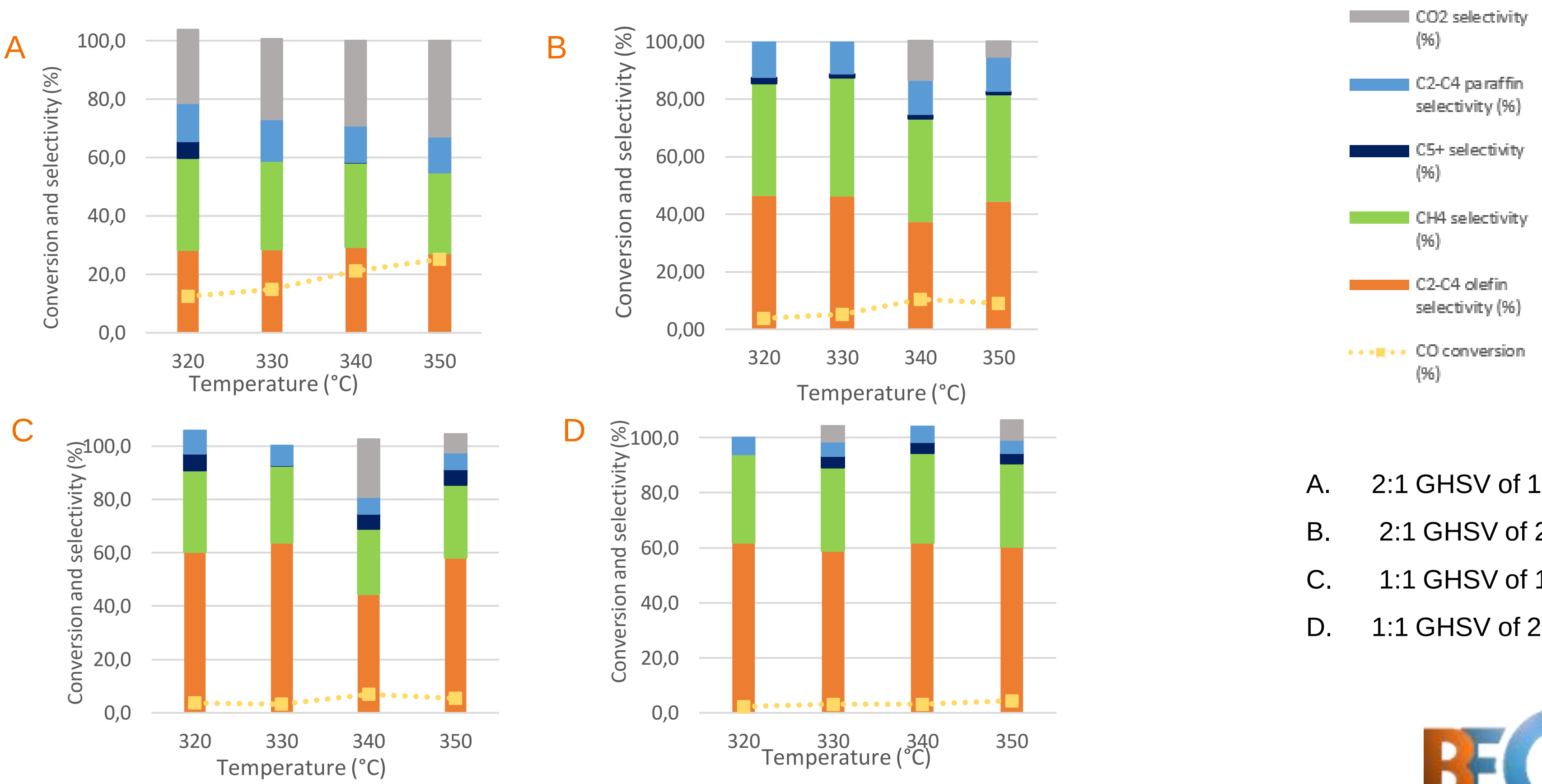


Comparison between different iron catalysts



- GHSV 2200 h^{-1}
- H_2/CO ratio 2
- No gas recycling

Effect of GHSV and H_2/CO_2 ratio, Fe-Pb/SiO2 catalyst



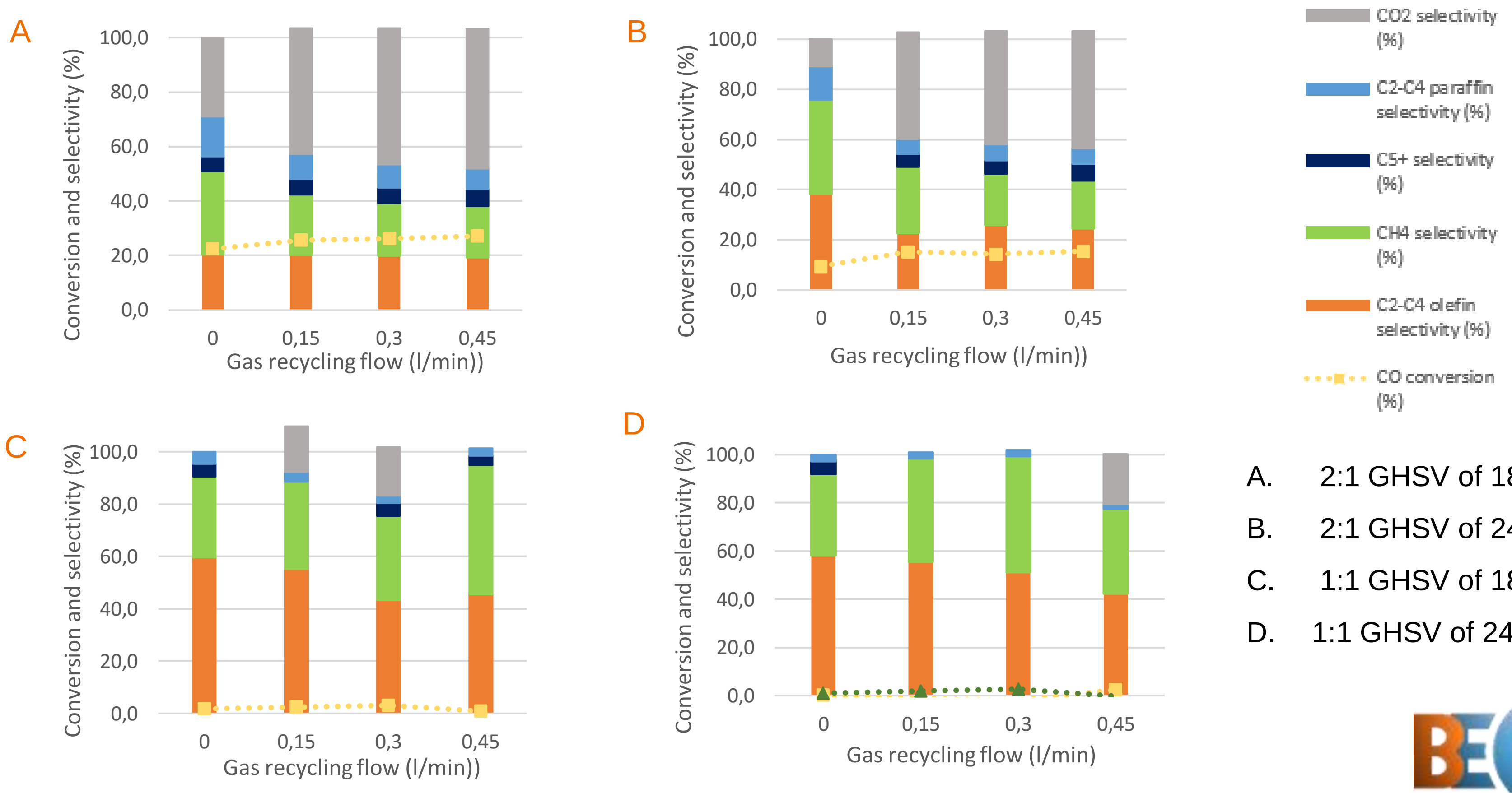
A. 2:1 GHSV of 1830 h^{-1}

B. 2:1 GHSV of 2460 h^{-1}

C. 1:1 GHSV of 1830 h^{-1}

D. 1:1 GHSV of 2440 h^{-1}

Effect of gas recycling, Fe-Pb/SiO2 catalyst



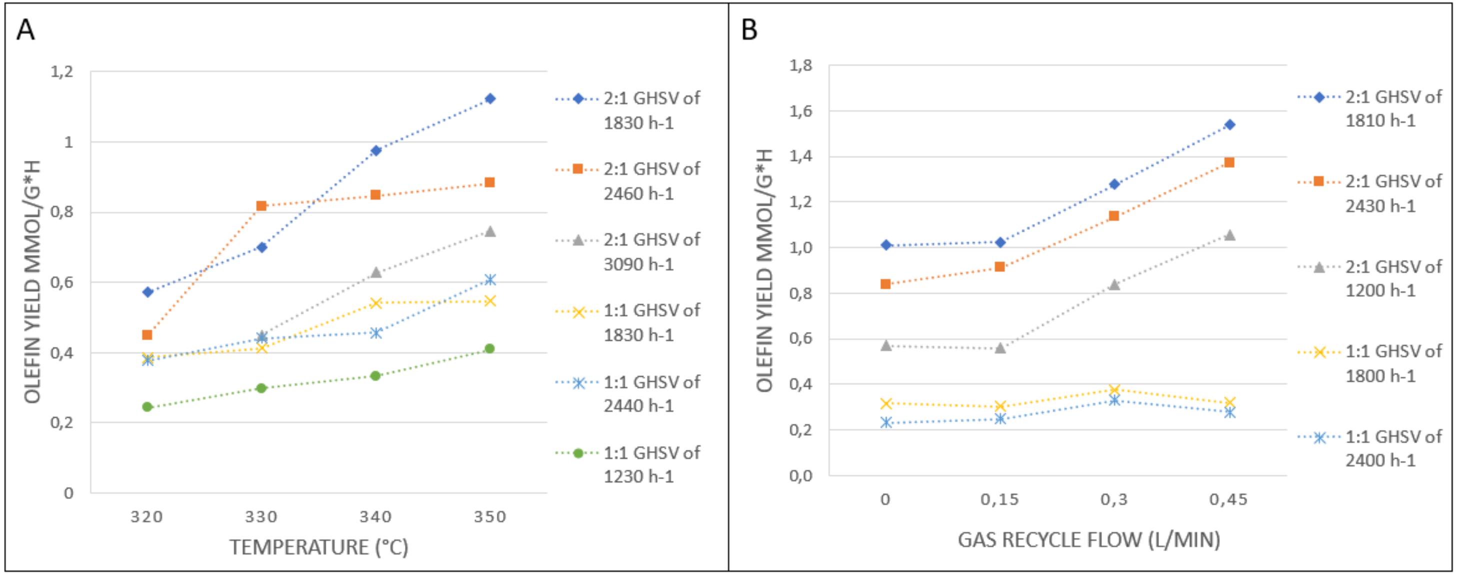
A. 2:1 GHSV of 1810 h-1

B. 2:1 GHSV of 2430 h-1

C. 1:1 GHSV of 1800 h-1

D. 1:1 GHSV of 2400 h-1

Light olefin yields at different process conditions, Fe-Pb/SiO2 catalyst



Conclusion

Project objectives were successfully achieved

- Integration of RWGS and FT reactors with working gas recycling system to produce light olefins from CO_2
- Fischer-Tropsch to olefins production developed by thorough catalyst testing
  - A lot of results – over 250 different set points tested
  - Six different catalysts, Fe-Pb/SiO_2 had the highest light olefin yield
  - Targeted light olefin selectivity of >45% achieved
- Good catalyst found but reactor design needs to be improved to diminish mass and heat transfer limitations when moving to larger scale.
- To take things further, the CO_2 to olefins process should be tested in a larger scale, downstream of electrolyzer and CO_2 capture

beyond the obvious

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