Novel Lithium Silicate-based Sorbents for High Temperature Carbon Dioxide Removal

Presented by

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Advanced Gasification Systems

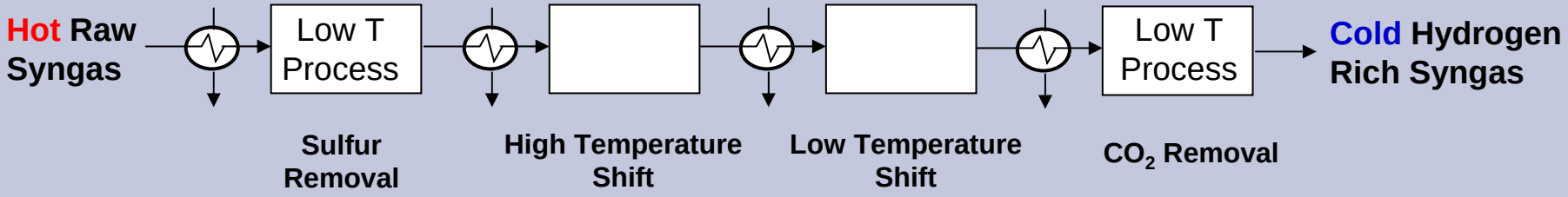
- System benefits that result in reduction of CO_2 emissions
  - High thermal efficiency
  - Conditions for CO_2 removal
    - High operating temperatures
    - High operating pressures
    - High CO_2 concentrations

CO_2 Removal Technologies

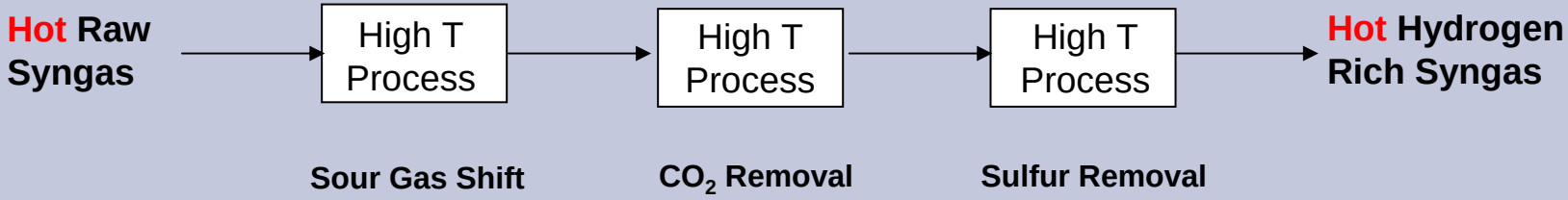
- Low temperature
  - alkanol amine-based solvents
  - cellulose acetate membranes
- High temperature
  - Regenerable sorbents
    - Li_4SiO_4
    - CaO
    - MgO

Process Integration

Commercially Practiced Process



Potential Elevated Temperature Process



CO_2 Sorbent Development Targets

- Effective at high temperature
  - For effective integration with other high temperature syngas cleaning technologies
- Regenerable
  - high purity, high pressure CO_2 by-product
- Highly tolerant to syngas contaminants (e.g., sulfur)
- Effective across wide range of CO_2 concentrations
- Suitable for both fixed or fluidized bed applications

Material Selection

Material Screening program

- Thermodynamic evaluation of potential candidates
- Thermogravimetric (TGA) analysis
  - Reactivity
  - Capacity

Lithium Ortho-Silicate

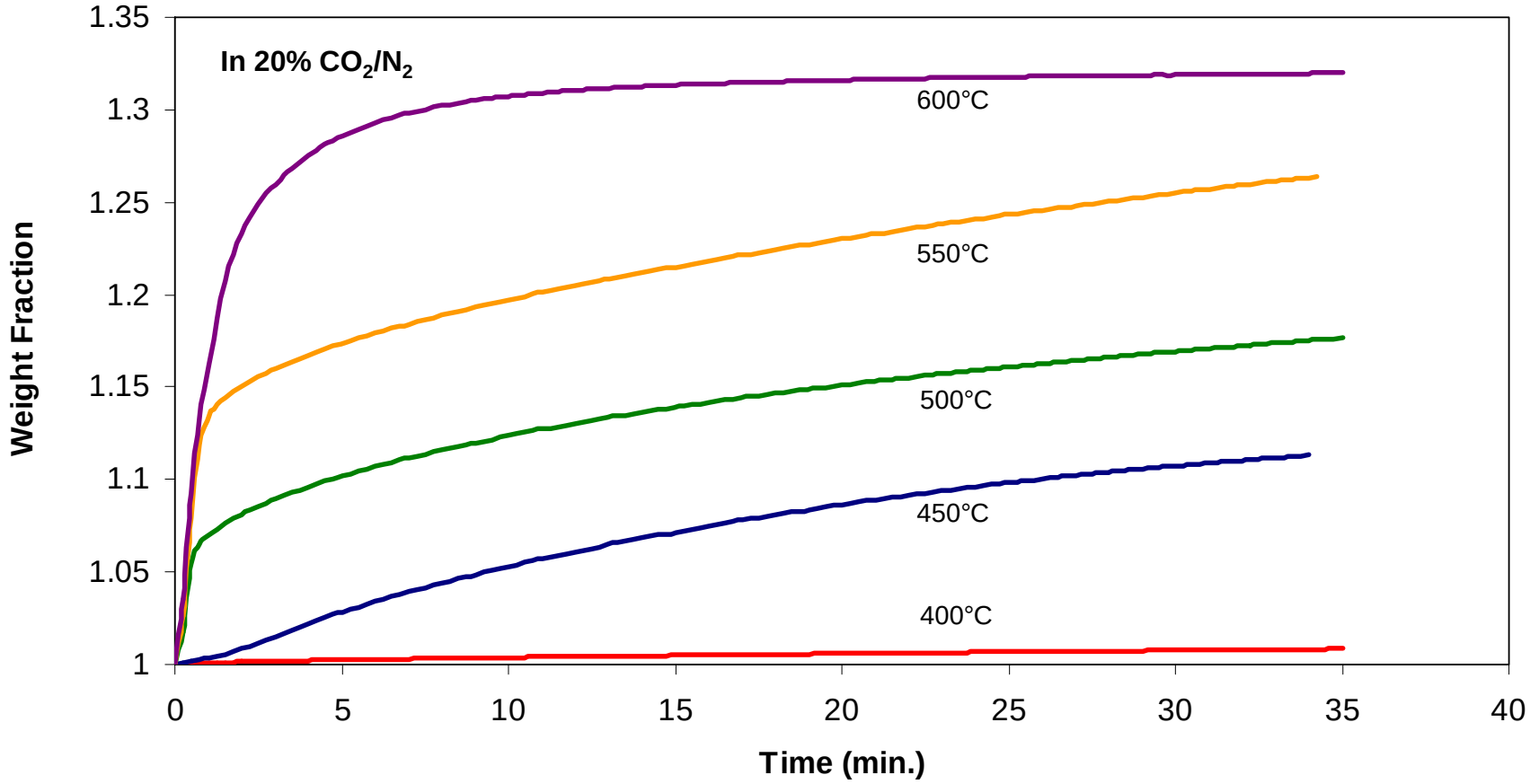
$$\underset{\text{(ortho)}}{Li_4SiO_4} + CO_2 \Leftrightarrow Li_2CO_3 + \underset{\text{(meta)}}{Li_2SiO_3}$$

Parametric Testing of Li_4SiO_4 Sorbent Synthesis

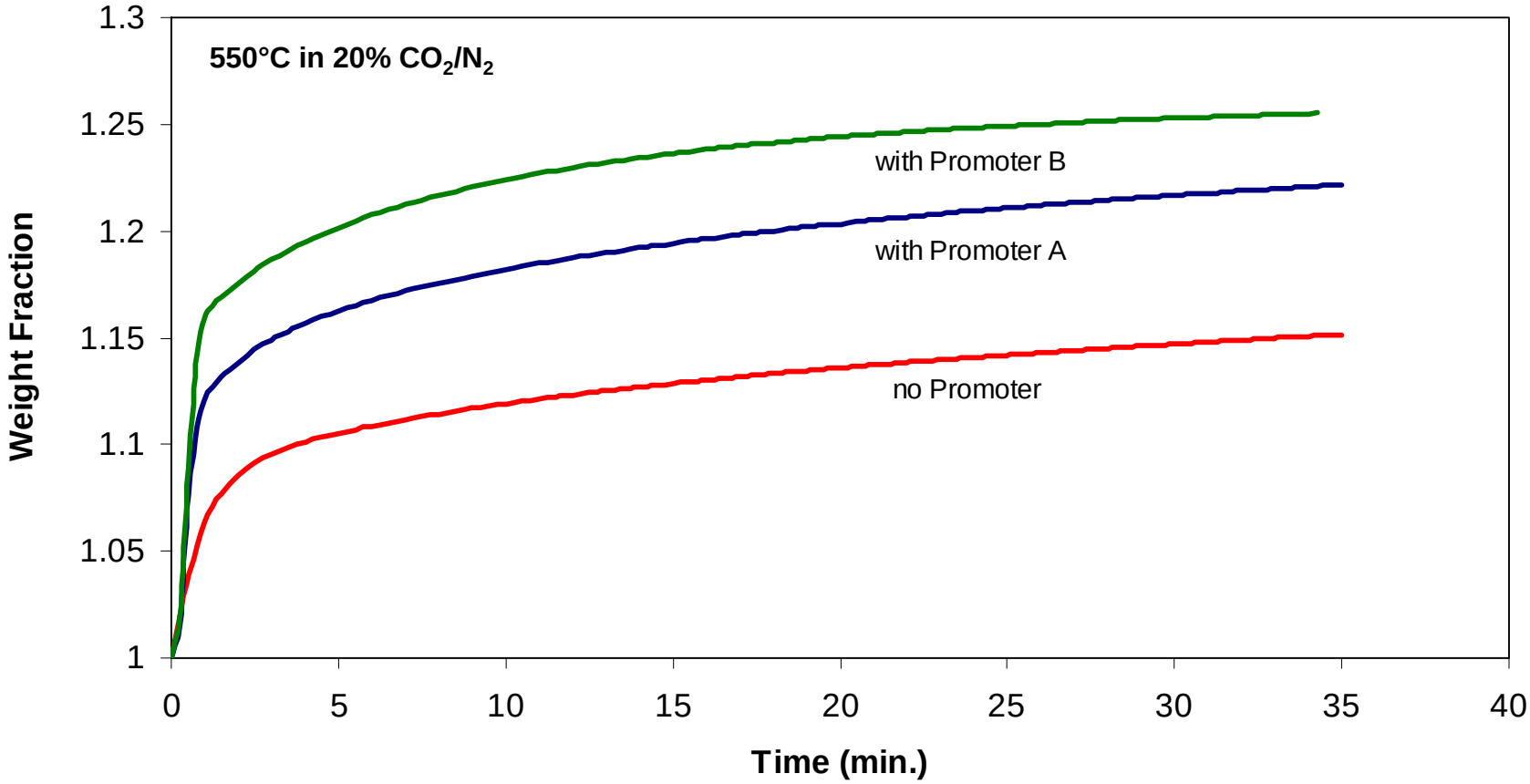
- Li_2O and SiO_2 precursors
- Promoters
- Mixing methods
- Calcination temperature
- Calcination time

Identified synthesis conditions necessary for production of Li_4SiO_4 sorbents with very promising CO_2 removal performance

Reaction Temperature Screening



Effects of Promoters



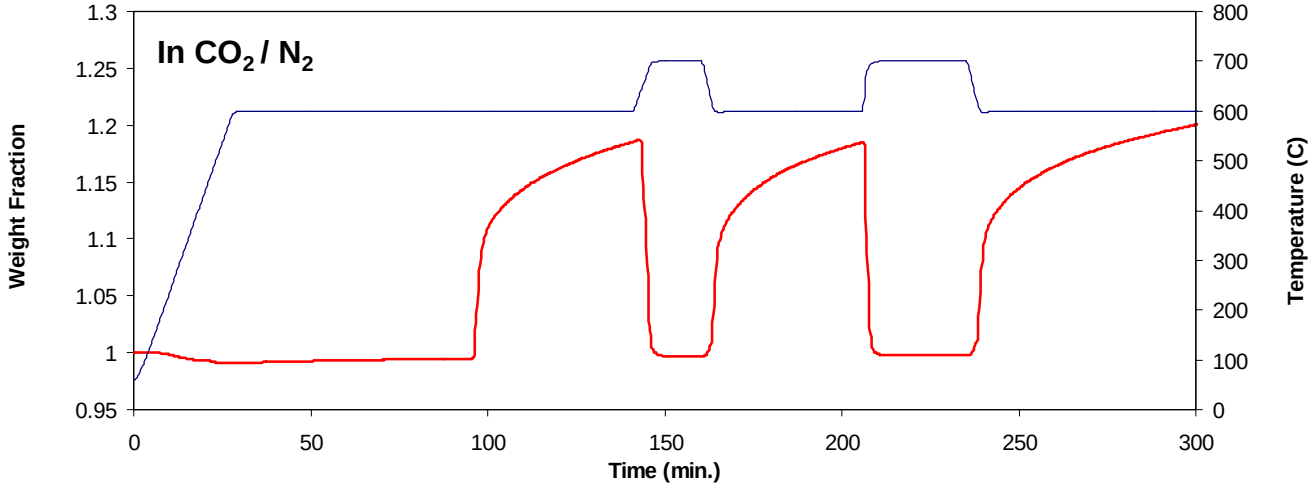
Effects of Gas Composition and Promoters

	CO_2 Capacity* (wt%)		
	in 20% CO_2/N_2	in clean syngas	in raw syngas
Without promoter	9	17	19
With Promoter A	16	22	25
With Promoter B	23	29	30

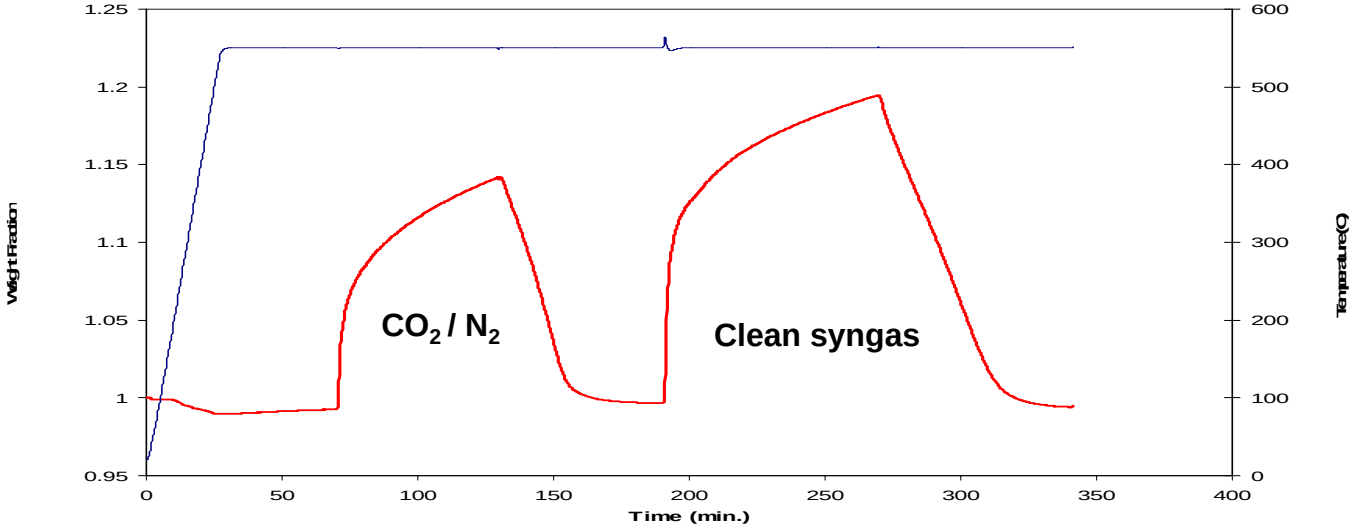
* Capacity equals wt% increase after exposure to CO_2 mixture for **10 min. at 550°C**

Potential Regeneration Modes

Temperature Swing

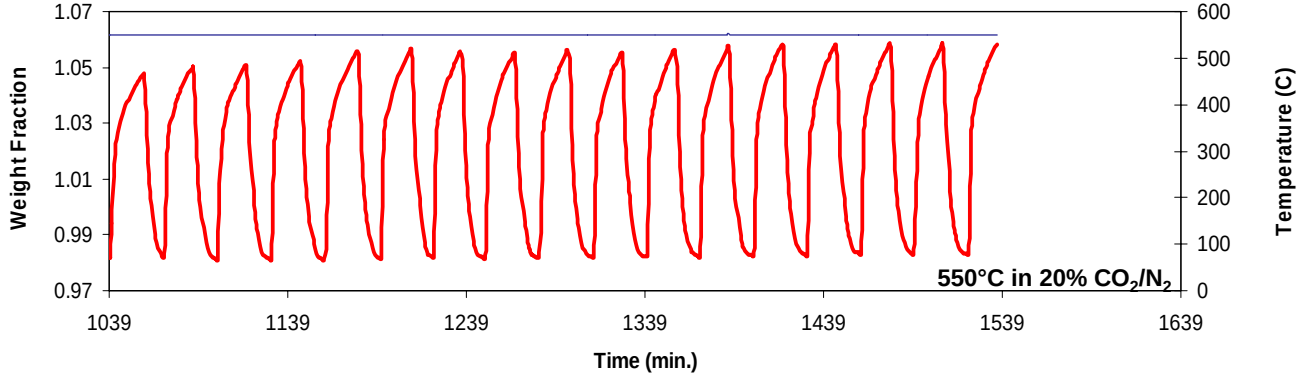


Inert Purge

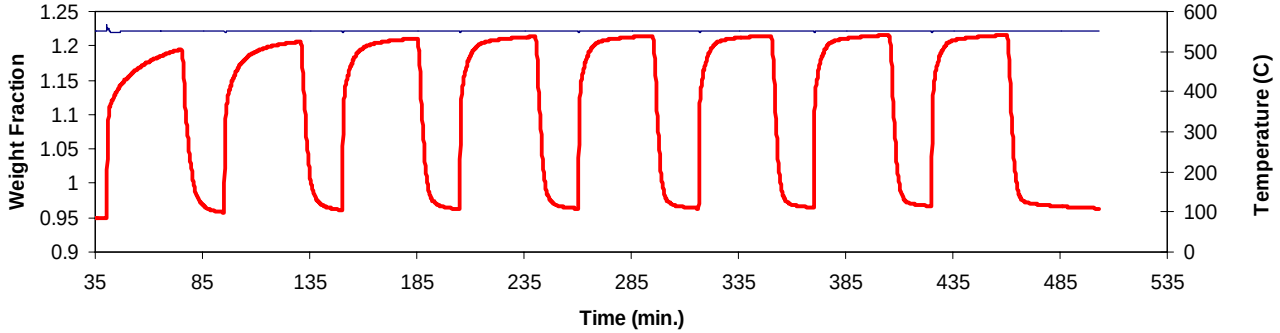


Multicycle Performance

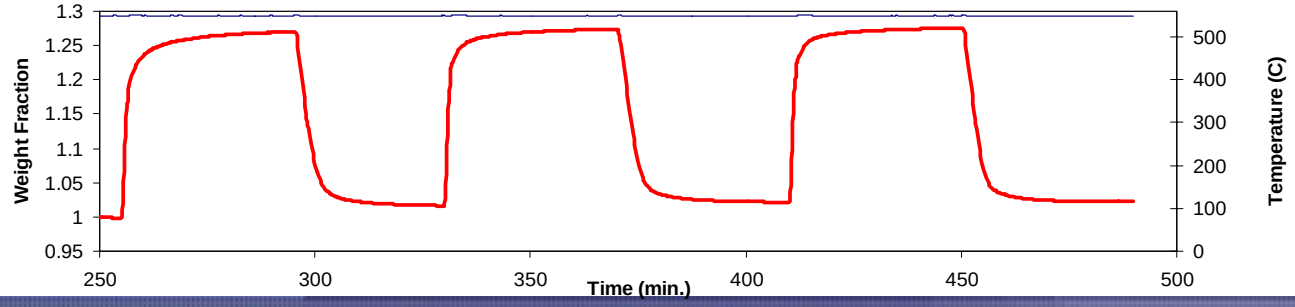
CO_2 / N_2



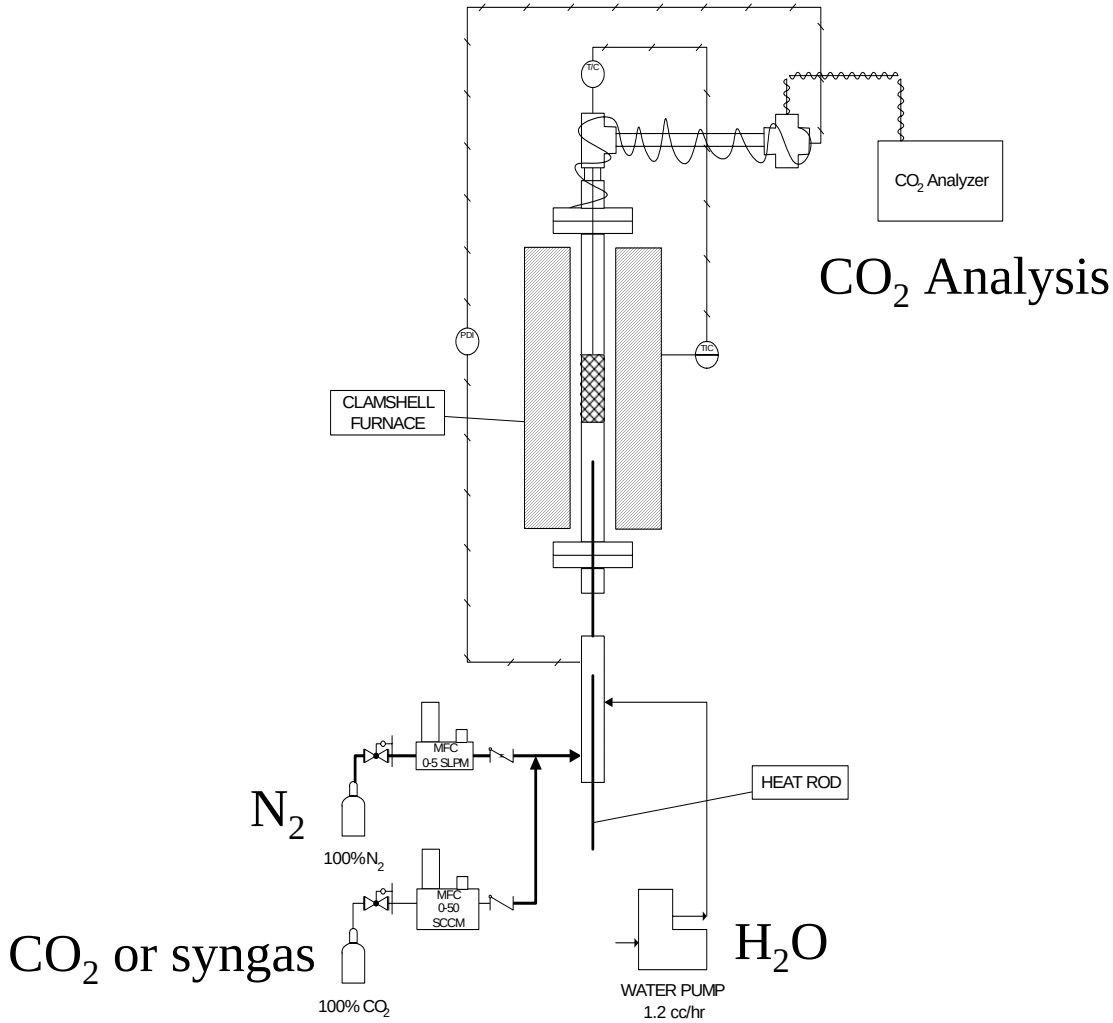
Clean Syngas



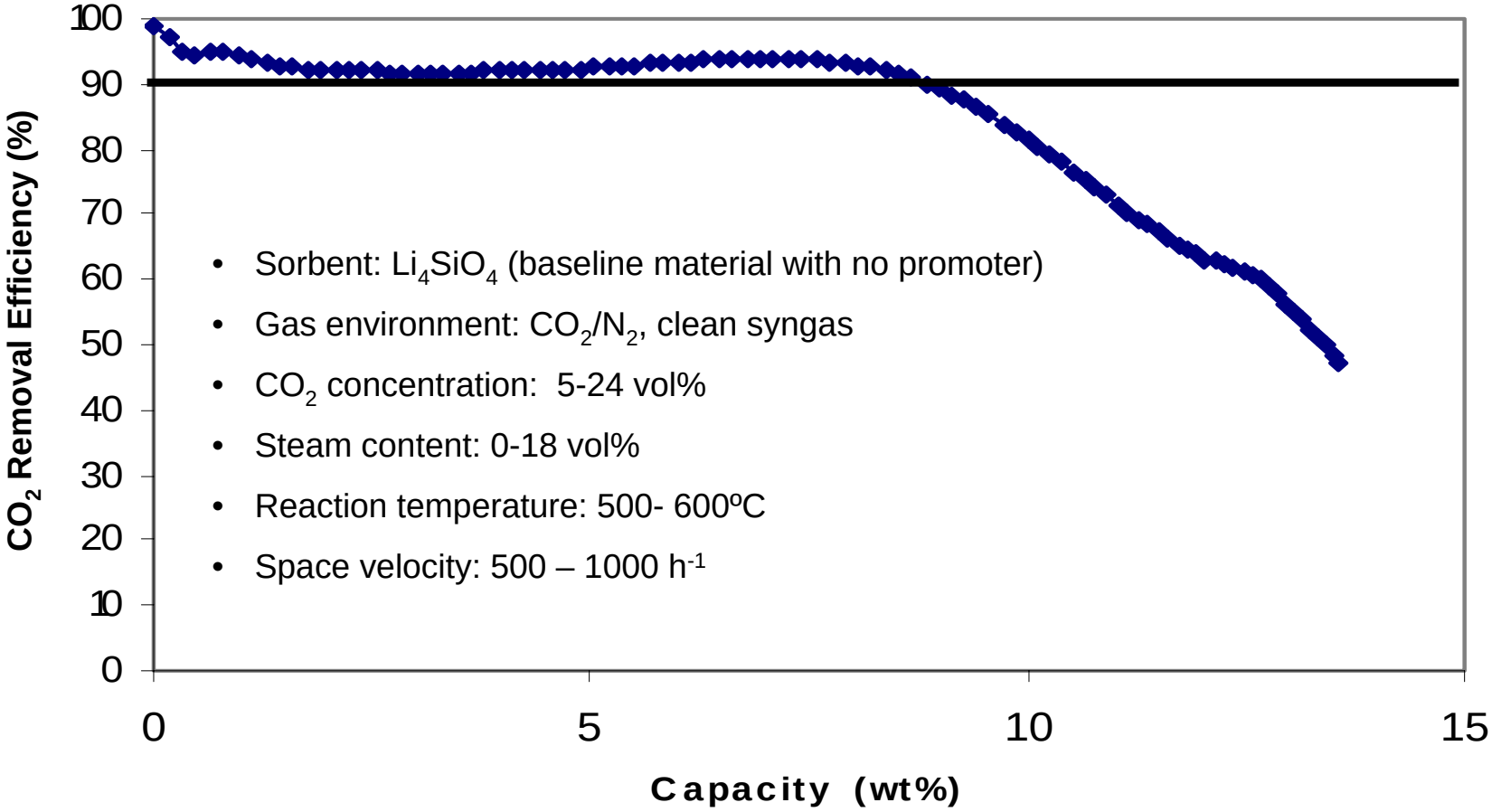
Raw Syngas



Microreactor System



Microreactor Performance Results



Summary

- Lithium silicate is a very promising candidate:
  - Effective in multiple gases, particularly sulfur-containing syngas
  - Regenerable
  - Stable multicycle performance
  - Effective promoters identified
  - Promising bench-scale testing results
- Future work
  - Reactor/process optimization
  - Sorbent development/optimization
  - Economic/engineering analysis

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