3D printed adsorbents for carbon capture applications

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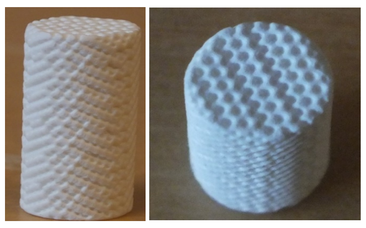
Introduction

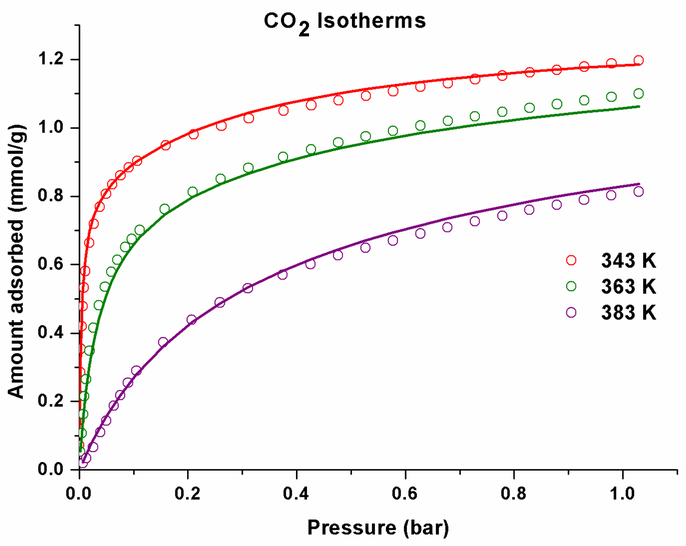
- **Structured adsorbents: better mass transfer and lower pressure drop over traditional pellets**
- **These adsorbents can be prepared by 3D printing: controlled channel sizes can be obtained**
- **Supported amine sorbents for better moisture tolerance**
- **Objective: To demonstrate an improvement in productivity over conventional pellets**

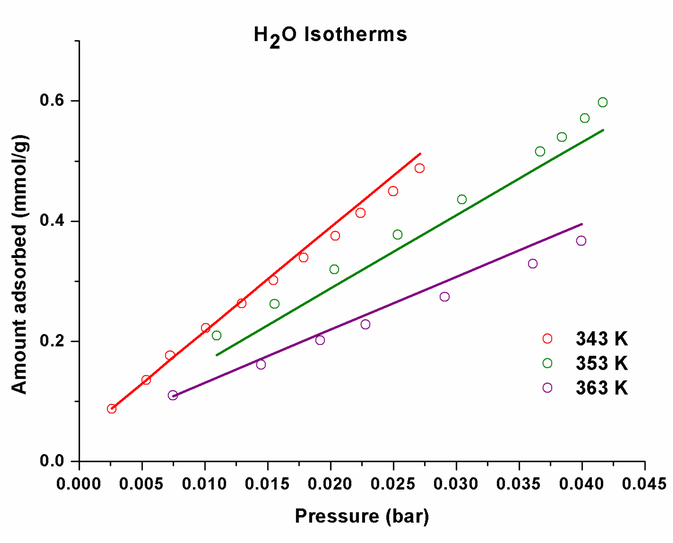


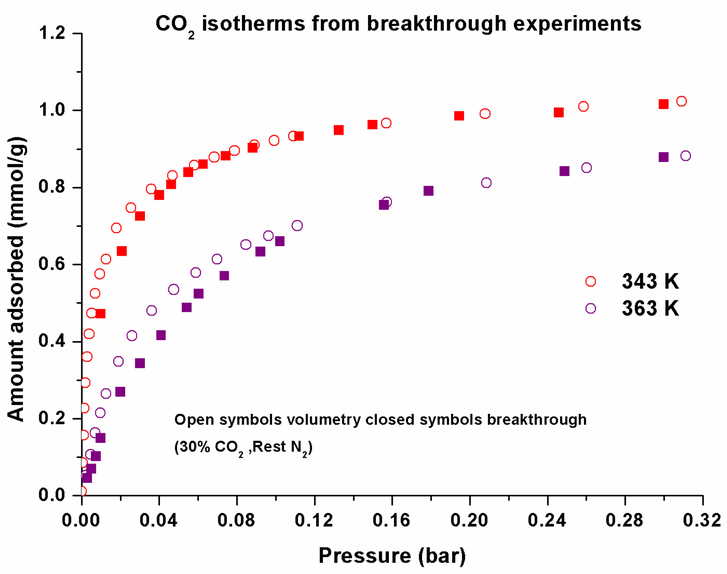
3D printed silica adsorbents grafted with poly-amino silane (channel diameter 0.3 mm, wall thickness 0.25 mm)

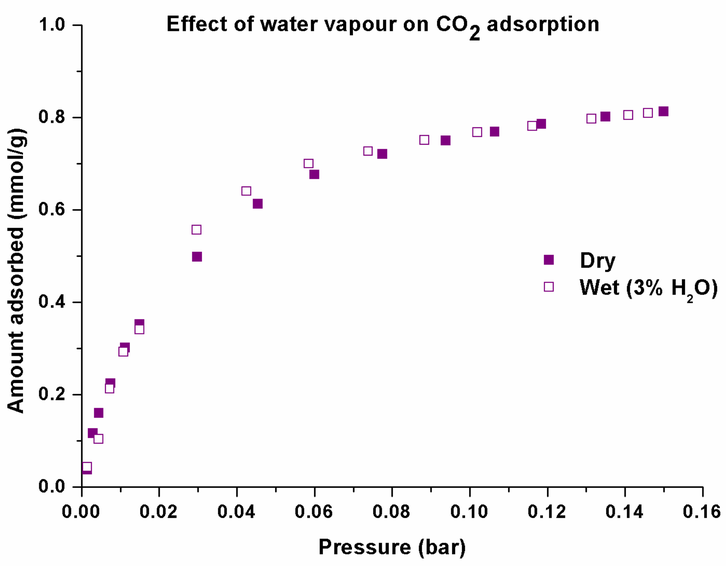
Adsorbent characterization

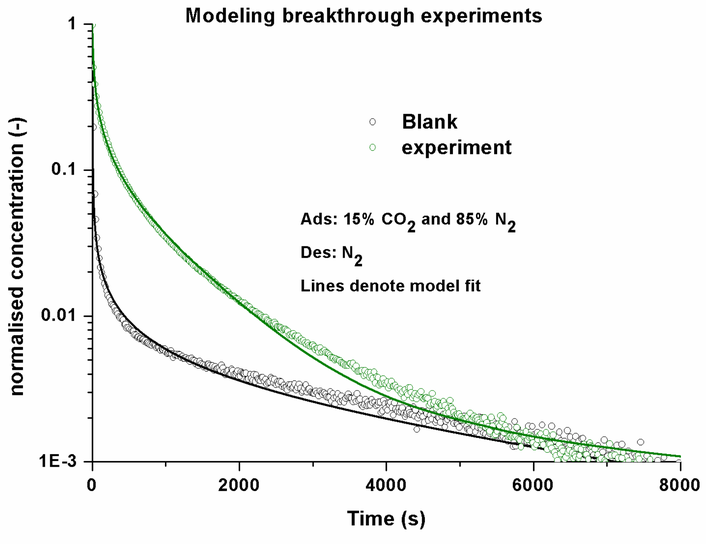
- **Single component isotherms by volumetry**
  - **Dual site Langmuir model (DSL) for CO_2 and H_2O**
  - **Heat of adsorption –111 kJ/mol for CO_2, –39.7 kJ/mol for H_2O**
- **Competitive CO_2+ H_2O isotherms by dynamic column breakthrough experiments**
  - **No loss in CO_2 capacity observed in the presence of water**
- **Mass transfer kinetics obtained by modeling breakthrough experiments**

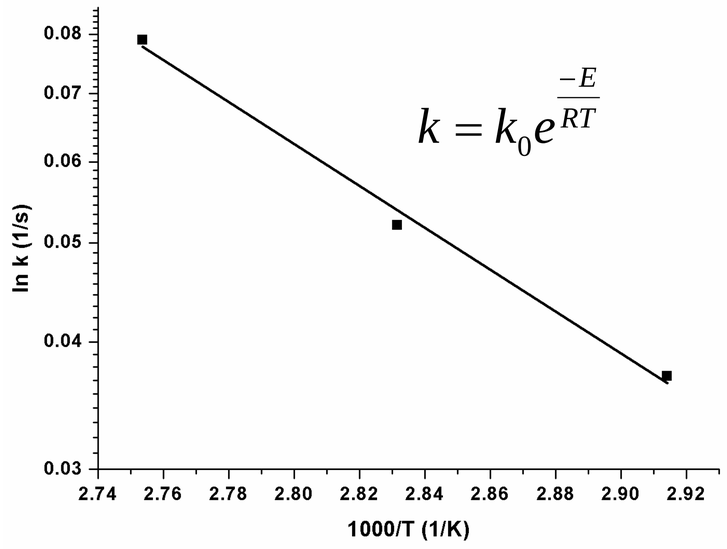




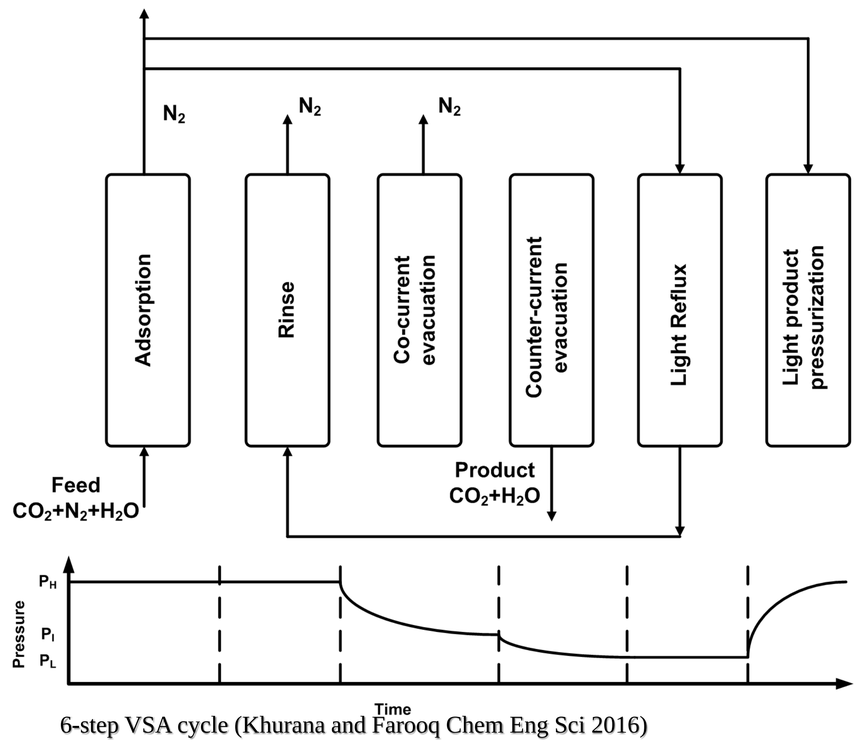








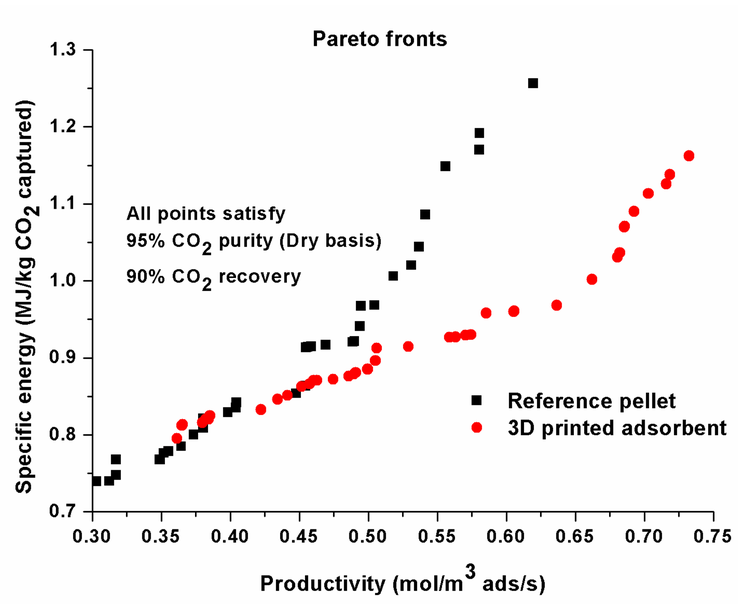
Process simulation & optimization



6-step VSA cycle (Khurana and Farooq Chem Eng Sci 2016)

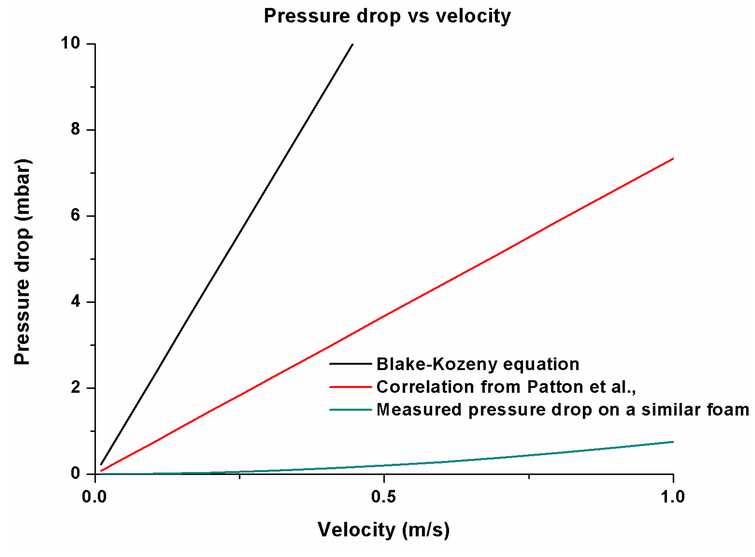
- **Input conditions: Feed 15% CO_2, 5% H_2O rest N_2 1 atm 363 K**
- **Genetic algorithm based optimization to identify operating conditions with minimum energy and maximum productivity**
- **Pressure drop and mass transfer co-relations for structured adsorbent obtained from literature (Patton et al., 2004, Ahn and Brandani 2005)**
- **Single component CO_2 isotherms at ternary conditions, competitive DSL model for N_2 and H_2O**
- **Decision variables : Adsorption, evacuation and reflux step times, evacuation pressures and feed flow rate**

Results & discussion



Performance indicators at maximum productivity

Adsorbent	Purity (%)	Recovery (%)	Specific energy (MJ/kg)	Productivity (mol/m^3 ads/s)
3D printed	98	90.7	1.16	0.73
Pellet	96	90.7	1.25	0.62



Conclusions & Future work

- **Improvement in process performance observed with 3D printed adsorbents**
- **Pressure drop tests and optimization needed to get true potential**
- **H_2O effect at higher partial pressures (5kPa) on CO_2 adsorption to be understood**

Acknowledgment