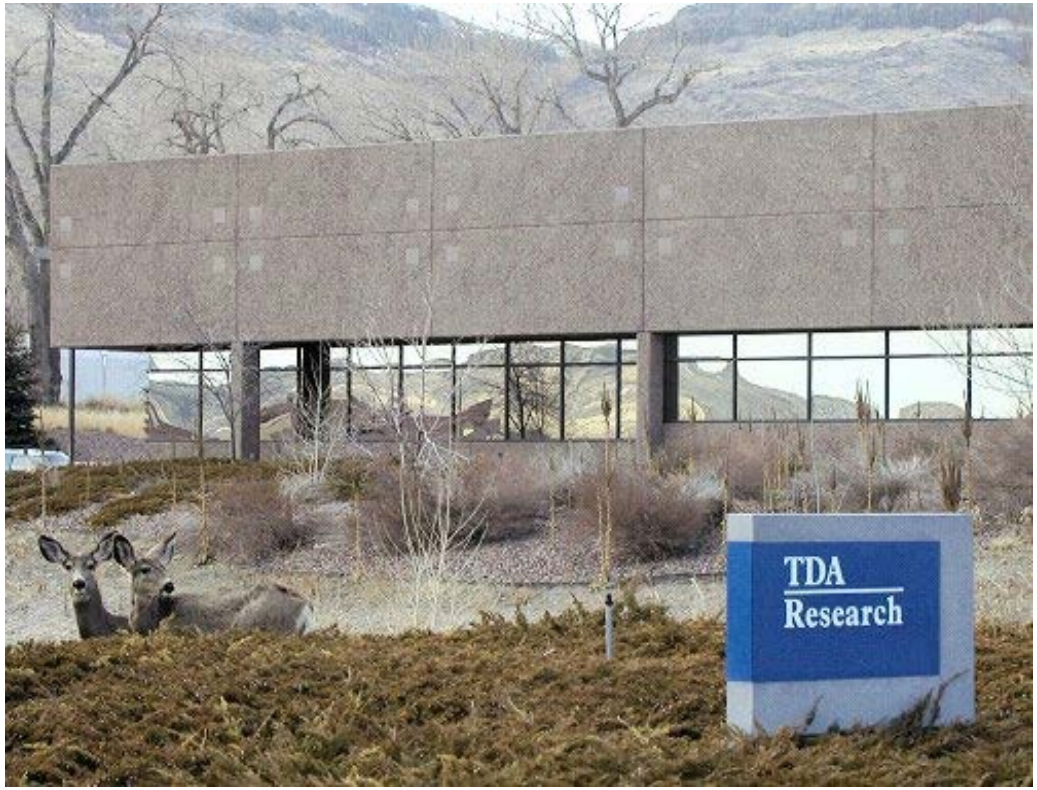
Transformational Sorbent System for Post Combustion Carbon Capture (Contract No. DE-FE-0031734)



Gökhan Alptekin

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2019 Carbon Capture, Utilization, Storage, and Oil & Gas Technologies Integrated Review Meeting

Pittsburgh, PA

August 26-30, 2019

TDA Research Inc. • Wheat Ridge, CO 80033 • www.tda.com

Project Objective

- **Objective is to develop a transformational sorbent system that can:**
  - Capture more than 90% of CO_2 emissions
  - Recover CO_2 at 95% purity
  - Reduce COE by 30% more than can be achieved by amine based systems and achieve capture cost less that $30 per tonne of CO_2
- **A highly stable high capacity metal-organic framework (MOF) based physical adsorbent is being developed to remove CO_2 from the flue gas using a novel adsorption cycle scheme**
- **Main Project Tasks**

BP1 **- Demonstrate sorbent performance in lab scale**

- Assess impact of flue gas contaminants (SO_2, NOx, HCl)

- Develop adsorption cycle sequence

- Preliminary Techno-economic analysis (TEA)

BP2 **- Scale-up sorbent production**

- Complete Life Tests

- Optimize adsorption cycles and update TEA

BP3 **- Complete field tests (6 months duration)**

- High Fidelity TEA and EH&S assessment

TDA RESEARCH

Project Team

NATIONAL ENERGY TECHNOLOGY LABORATORY

TDA RESEARCH

UNIVERSITY OF ALBERTA

UNIVERSITY of CALIFORNIA • IRVINE

ITC WYOMING INTEGRATED TEST CENTER

Overall Project Duration

- Start Date = June 1, 2019
- End Date = May 31, 2022

Budget

- Project Cost = $3,750,000
- DOE Share = $3,000,000
- TDA and its partners = $750,000

Budget Period 1 Duration

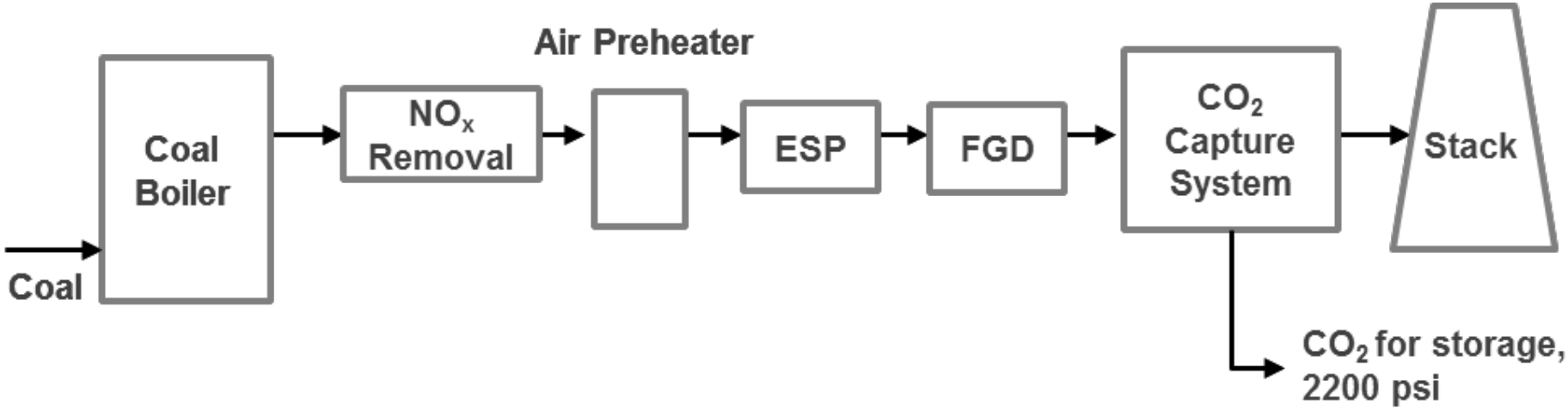
- Start Date = June 1, 2019
- End Date = May 31, 2020

Budget

- Project Cost = $1,212,387
- DOE Share = $969,887
- TDA and its partners = $242,500

TDA RESEARCH

TDA's CO_2 Capture Process

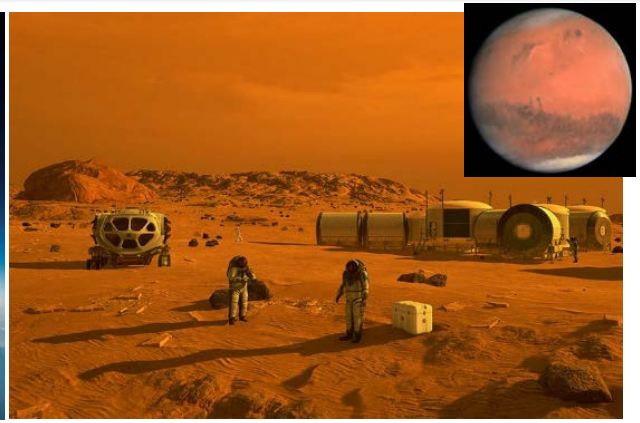


- Sorbent operates at ~50-60°C during adsorption
- Various options will be explored for the regeneration
  - Vacuum swing adsorption (VSA) - mild vacuum (0.2-0.3 atm) under isothermal conditions
  - Temperature swing adsorption (TSA) – mild TSA (40-70°C max) to recover CO_2 at high pressure
  - Concentration swing adsorption (CSA) – use low grade steam
  - Any combinations above

Previous Sorbent Development

CO_2 Removal from Portable Life Support System using space vacuum

- High vacuum (1-2 torr)
- Low water (a sublimator is in place)
- VSA -Adsorb at 2500 torr regenerate at 1 torr



Harvesting CO_2 from Mars to produce propellants for return trip using TSA

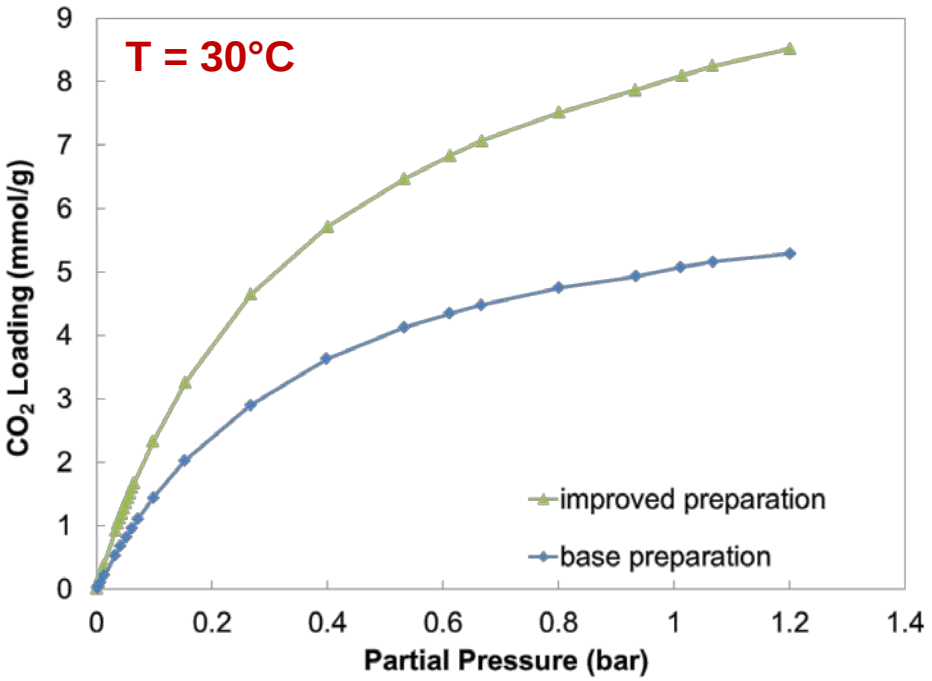
- TSA -Adsorb at 5 torr regenerate at 3800 torr (5 atm)
- Very low water

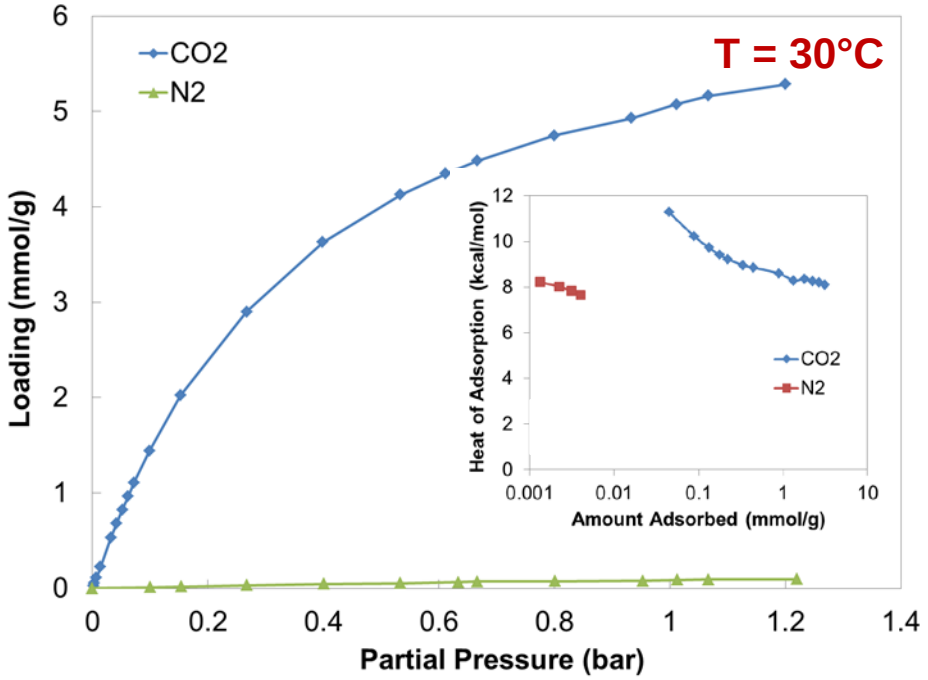
Removing CO_2 from Virginia Class Submarines using VSA/TSA

- 130 person crew
- Adsorb at 5000 torr 30^{o}C and regenerate at 760 torr at 100^{o}C(1 atm)
- High water

- **We also completed a DOE SBIR Phase I project, showing the potential of the new sorbent in post-combustion capture (removing CO_2 from low concentration generators, such as NGCC plants)**
  - VSA, high moisture

TDA's MOF Sorbent

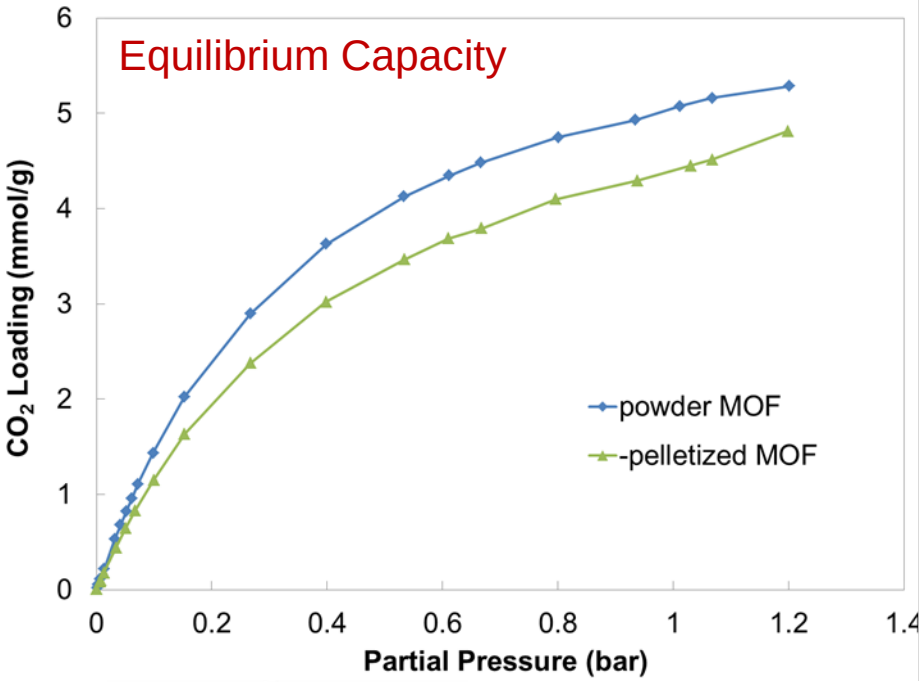


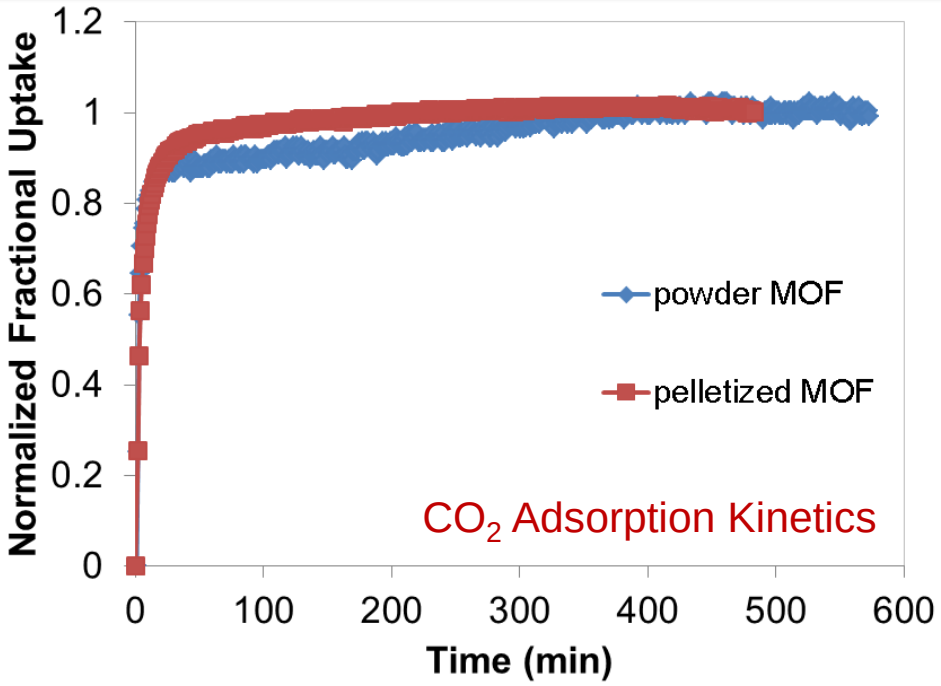


- Very high CO_2 uptake (2-3 mmol/g) at 0.15-0.20 bar CO_2 partial pressure
- High CO_2 selectivity over N_2
- Relatively low energy input requirement for sorbent regeneration

	Selectivity
P_{CO2} (bar)	CO_2/N_2
0.05	9.32
0.1	16.29
0.15	22.92
1	57.52

Powder Vs Pellets



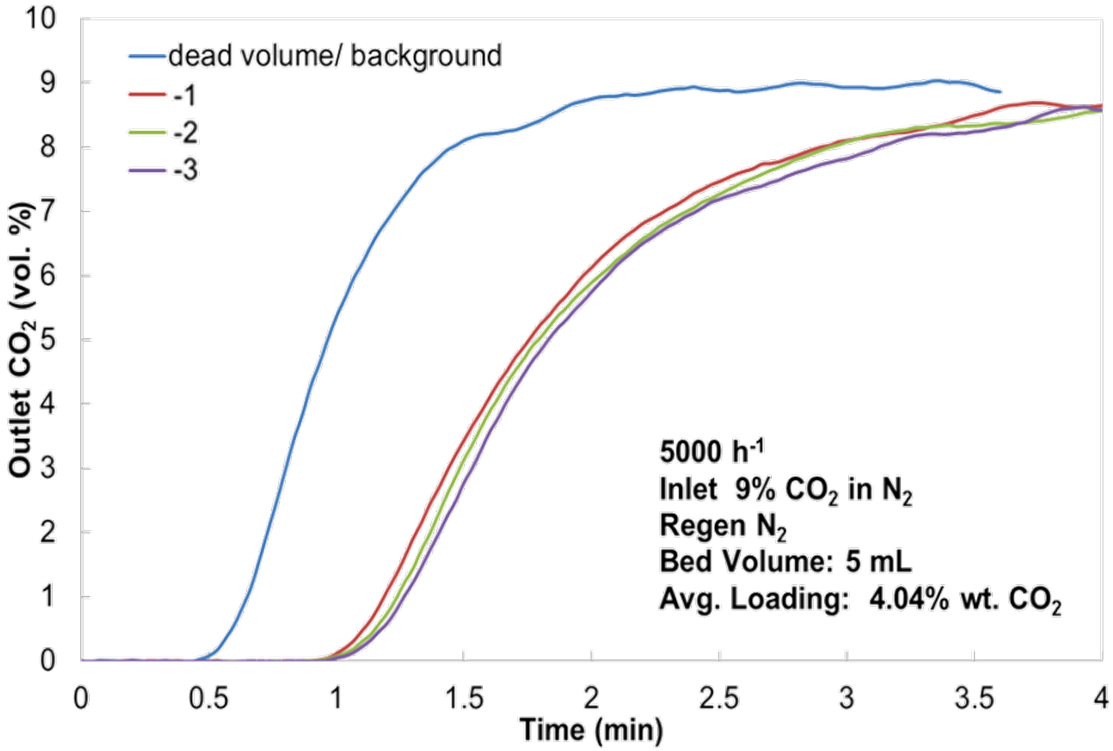


- **TDA developed a palletization method using pill press**
- **TDA's MOF had a marginal loss in CO_2 adsorption capacity due to pelletization, while the rate of the adsorption (kinetics) met requirements**

Fixed Bed Reactor Tests

- CO_2 capacity of the pelletized sorbent was measured in a fixed bed test unit

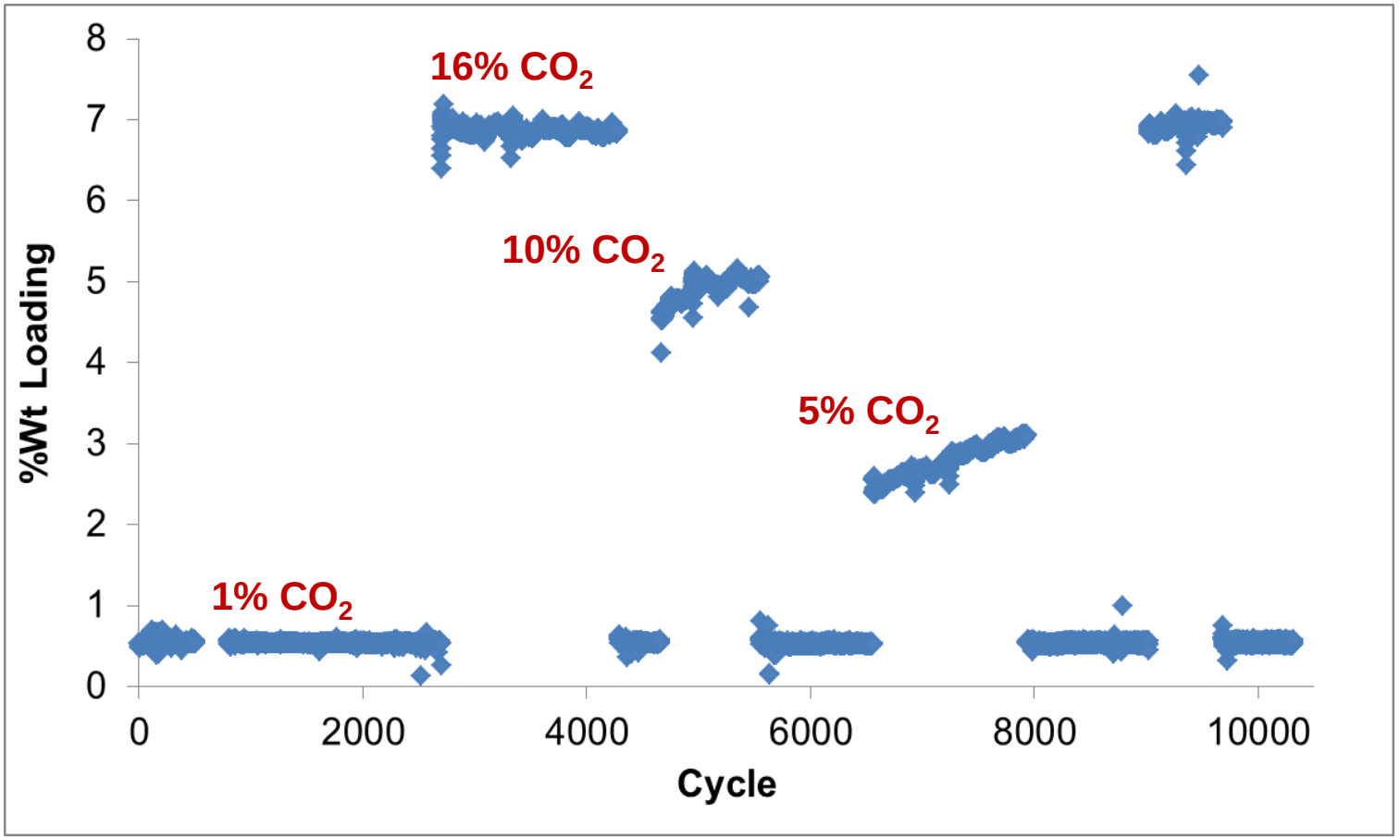
Adsorption: 12.6% CO_2, 86 ppm NO, 73 ppm SOx in N_2; 10,000 h^{-1}
Desorption: N_2 T = 25°C



- The sorbent achieved a CO_2 capacity of 4.0% wt. CO_2
- CO_2 capacity is not degraded upon exposure to NO and SOx

Life Tests in TGA

Adsorption: 1, 5 , 10 or 16% vol. CO_2 in N_2;
Desorption: N_2; T = 28°C



- **TDA's sorbent showed stable performance over 10,000 cycles**