A New Thermal Swing Adsorption Process for Post-Combustion Carbon Capture from Natural Gas Plants

PROJECT OBJECTIVE

Demonstrate the viability of a transformational microwave-assisted thermal swing adsorption (MTSA) carbon capture process to efficiently capture CO_2 from an NGCC flue gas (simulated) and demonstrate ≥ 25% reduction in the cost of capture relative to a liquid amine scrubber.

- Capture CO_2 from a simulated flue gas at NGCC point-source levels
- CO_2 capture efficiency target ≥ 95%
- CO_2 product purity target 95%

TEAM MEMBERS

TDA Research

SLB

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Membrane Technology & Research

APPROACH

<u>Budget Period 1</u>

- Material synthesis and production
- Adsorption, microwave heating, and CFD modeling
- Bench-scale system design and optimization
- Preliminary TEA

<u>Budget Period 2</u>

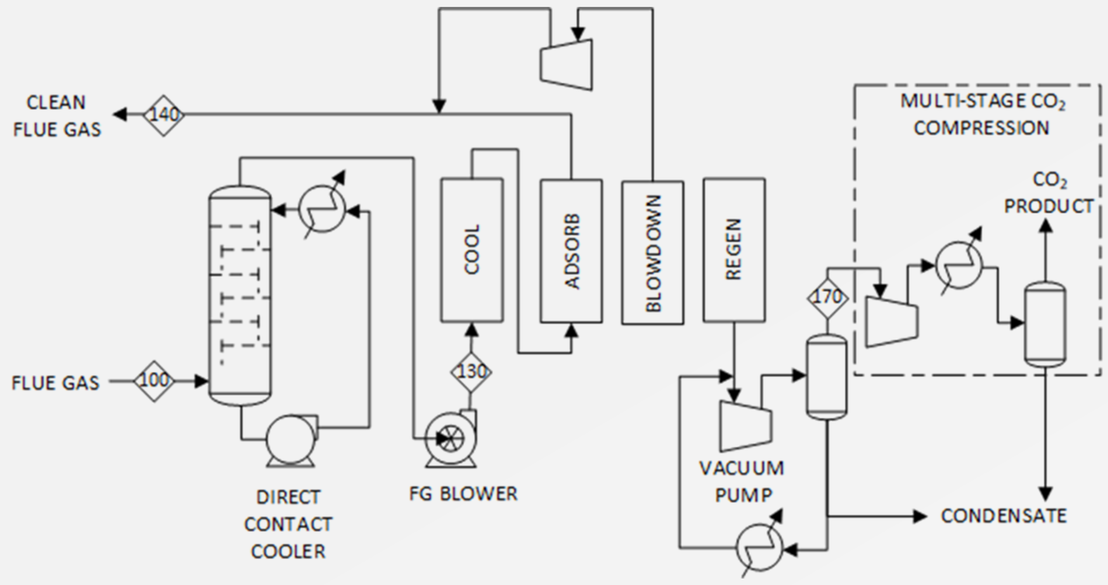
- Bench-scale system construction
- Bench-scale system commissioning and shake-down

<u>Budget Period 3</u>

- Bench-scale evaluations
- High-fidelity TEA
- Carbon life-cycle analysis (LCA) and environmental health and safety analysis

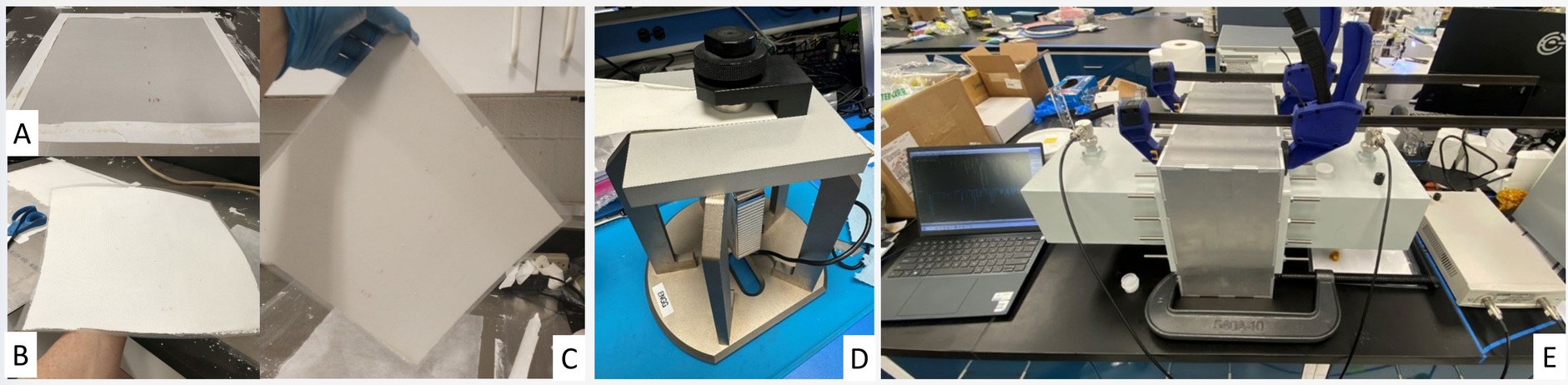
TDA's CO_2-selective sorbent

- Sorbent can be formed into mixed-matrix laminates to form structured gas-solid contactors with high utilization and low pressure drop
- CO_2 working capacity ≥ 4% wt. with NGCC-like flue gas streams
- Capture efficiency and product purity have been demonstrated at ≥ 95%
- Initial testing with contaminated flue gas is stable with SO_2 and NO_x

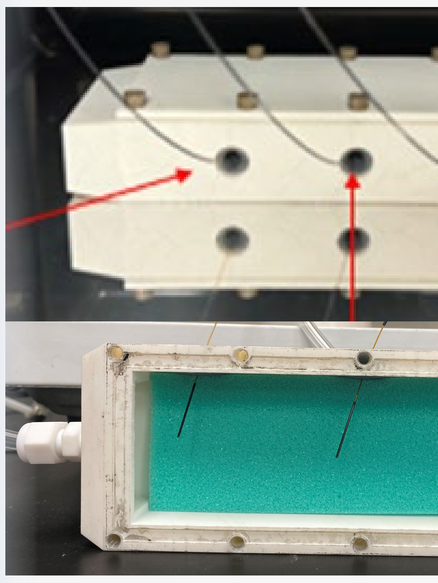


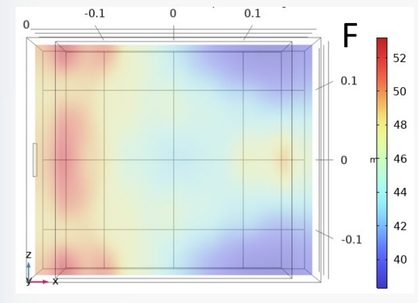
TDA's MTSA process is designed specifically to strip CO_2 from flue gas exiting the HRSG of an NGCC plant.

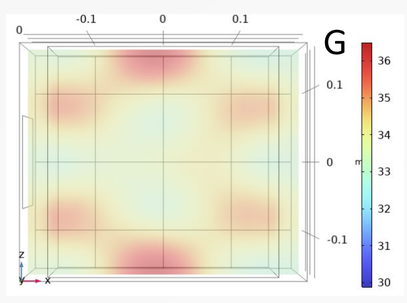
1. Flue gas passes through a pair (lead-lag) of solid-state CO_2 contactors (adsorption) wherein the sorbent selectively binds the CO_2
2. Once saturated, the contactor is evacuated (blowdown) to remove the void gas and improve the product purity
3. The contactor is rapidly heated (regeneration) via microwave energy and the CO_2 is desorbed as a high-purity product stream
4. The contactor is placed back into adsorption as the first bed in the lead-lag pair and cooled back to the adsorption temperature



TDA's laminate sorbent being cast as 12" x 12" sheets (A) and after curing (B and C). The sorbent's dielectric properties are measured with an epsilometer (D). The experimental sorbent properties are added to COMSOL, and the resulting models are validated using a vector network analyzer and custom microwave cavities (E). Modeling has been performed at 2.45 GHz (F) and 915 MHz (G).

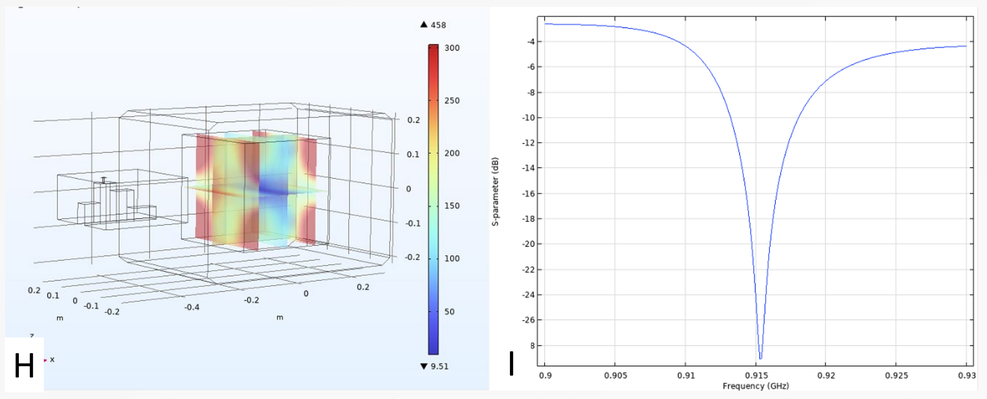




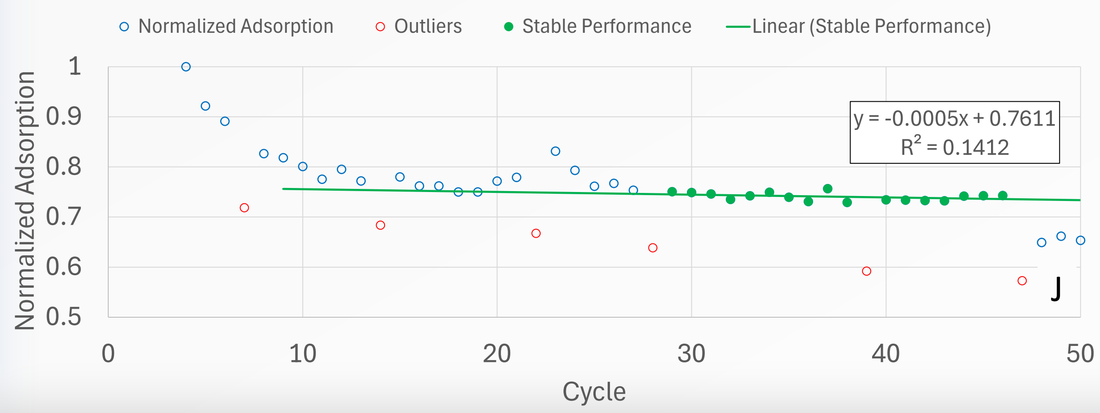


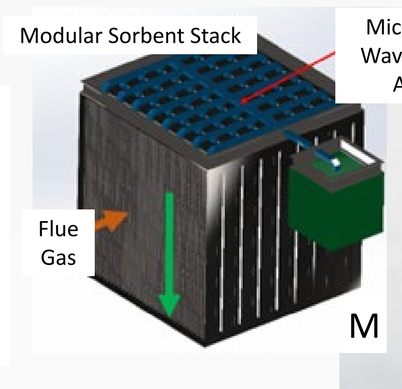
Comparison between 2.54 GHz (left) and 915 MHz (right)

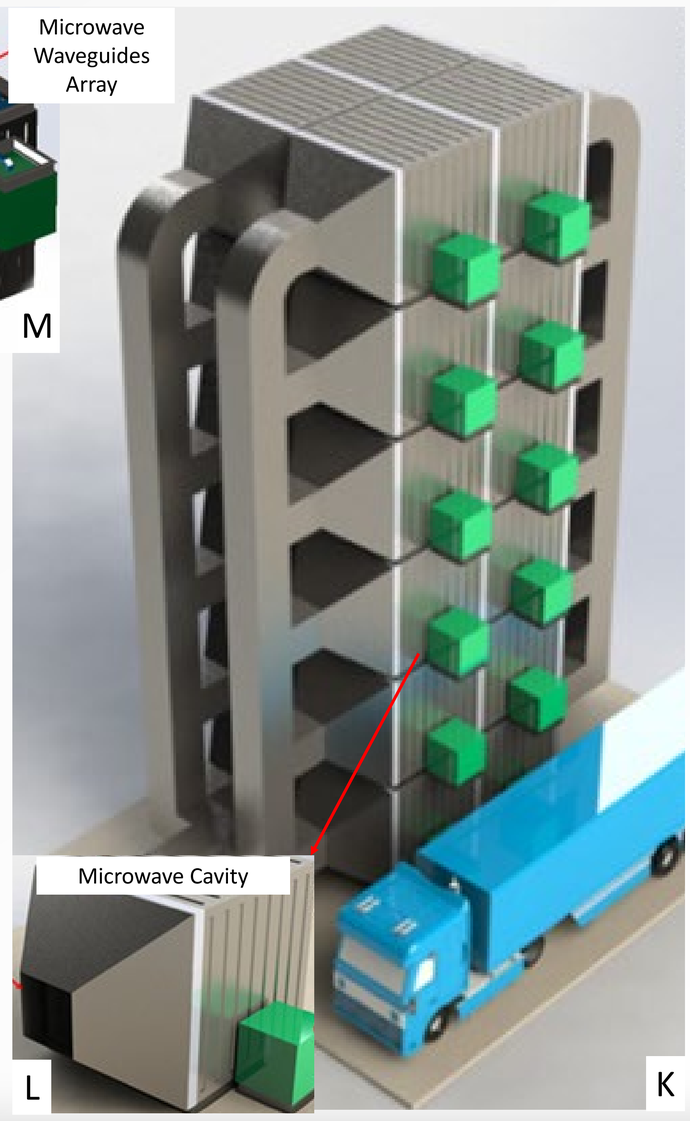
Preliminary render of a full-scale carbon capture system for an NGCC power plant (K). The system is constructed from modular microwave arrays (L) with several contactor units and combined with a waveguide network (M).



Optimized 915 MHz cavity/contactor (H), S-parameter plot (I), solid-state generator (I), and preliminary sorbent stability test results (J).







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