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Composite Solid Sorbent - Solvent Matrix for Capture of CO_2 from Mobile Systems

DE-SC0025105

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2024 FECM NETL Carbon Management Research Project Review Meeting

August 5 – 9, 2024

Project Overview

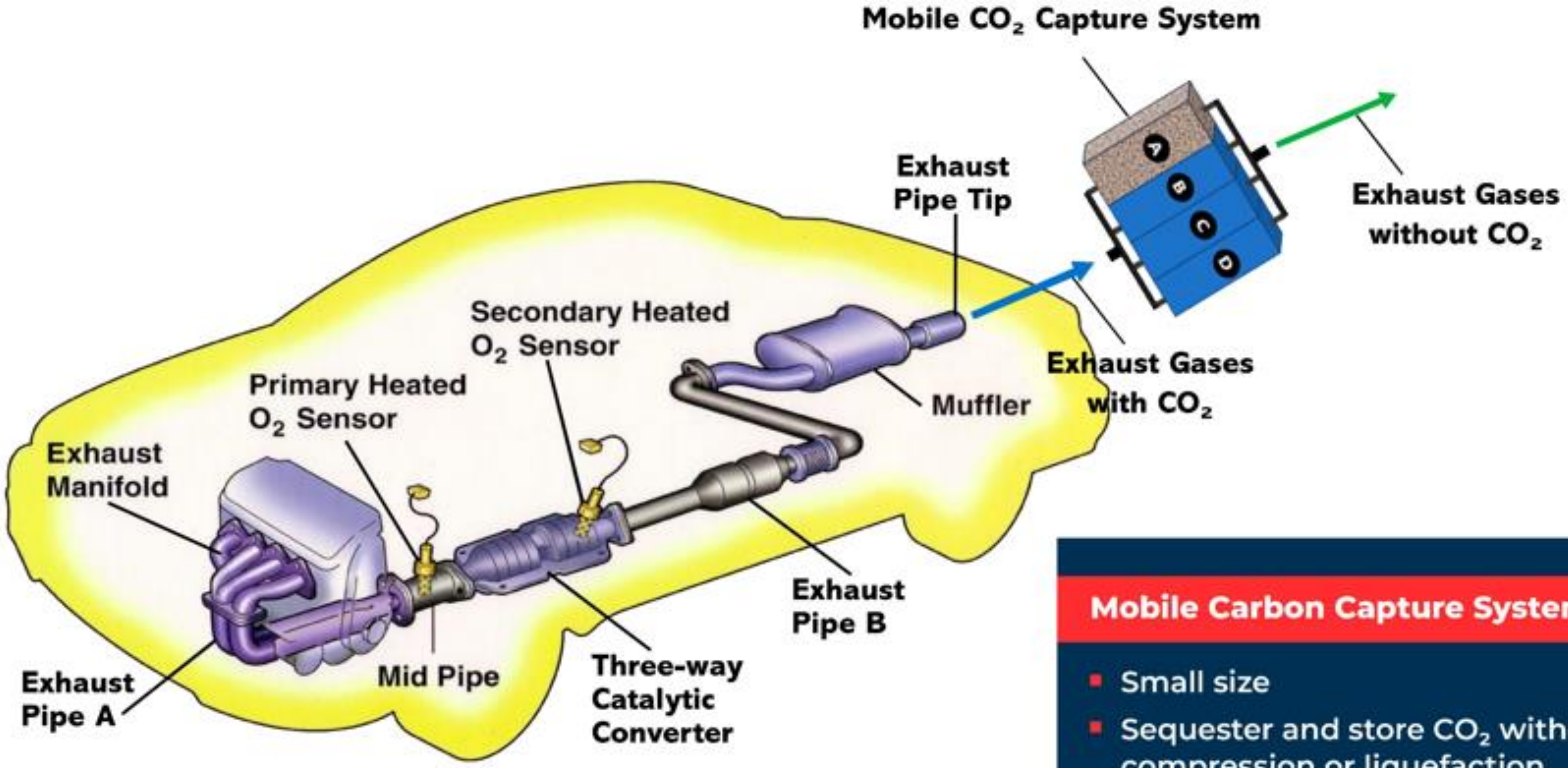
Objectives:

- Demonstrate feasibility of solid matrices to robustly sequester, store and transport CO_2 from cars, semis and heavy duty trucks, and long-range marine vessels
- Develop comprehensive technoeconomic analyses and LCA specifications for the proposed mobile CO_2 capture system(s).

Project details:

- Principal Investigator: Malcolm Fabiyi, PhD
- Duration: 9 months (7/22/2024 to 4/21/2025)
- Budget: $248,978
- Program Manager: Nicole Shamitko-Klingensmith, Ph.D., PMP

Technology Background



Picture of exhaust system from Alen Auto.

Mobile Carbon Capture System Features

- Small size
- Sequester and store CO_2 without compression or liquefaction
- Does not require online regeneration
- Modular, replaceable

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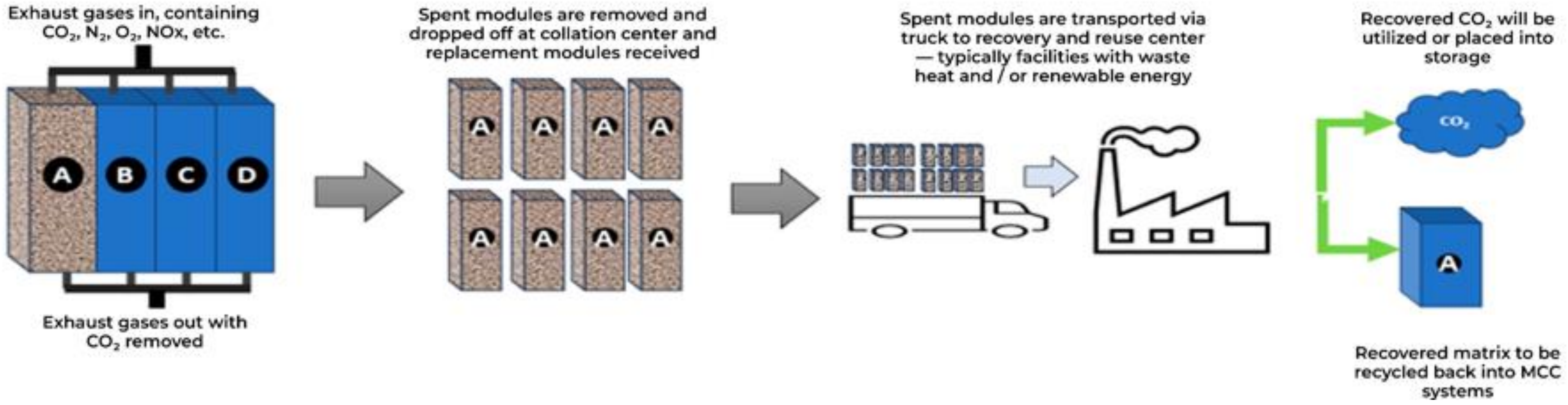
Technology Risks & Challenges



Simple, modular, compact, high-capacity systems

- **CO_2 storage and transport capable**
- **Stable matrix, no degradation of materials or release of CO_2**

- **Rapid, effective desorption**
- **Recyclable, reusable matrix materials**

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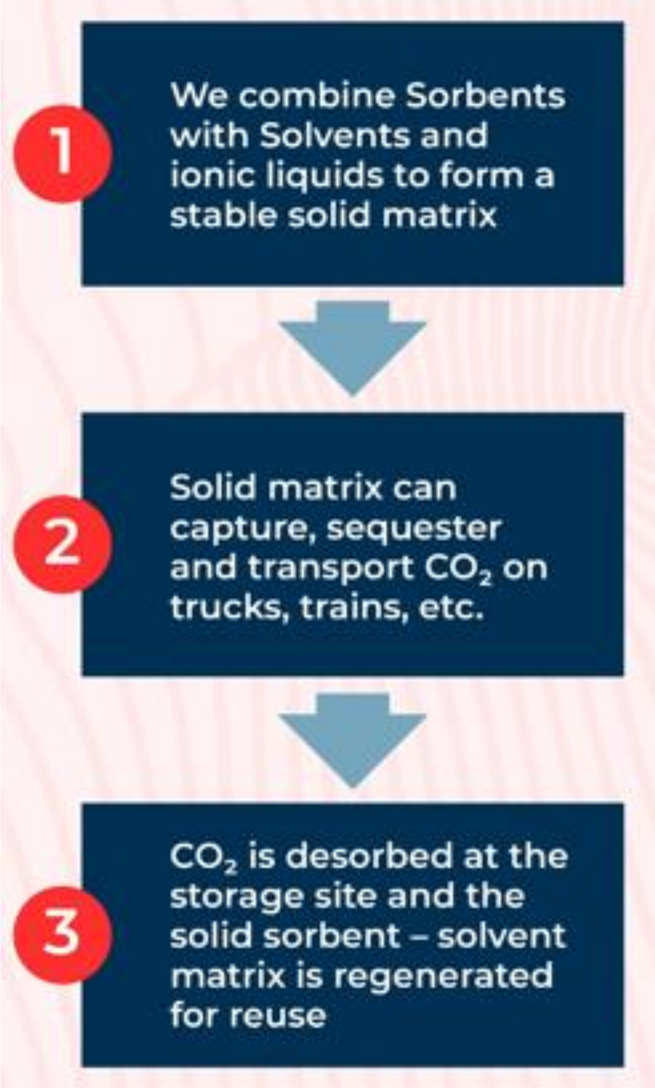
Technical Approach



*3.64 moles CO_2 per liter

Sample composite matrix with Amine + Metallic Oxide - 8 gm CO_2 captured in 50 mL matrix*

Tubes contains various solvent and matrix combinations with bound CO_2

Matrix with 50% w/w NaOH solvent and metallic oxide solid adsorbent. Resulting composite is safe to handle.

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Objective	Tasks	Month
1	**Determine suitable sorbents and solvents that can be utilized to make solid composite matrices that effectively sequester CO_2.:** Evaluate and characterize sorbent and solvent combinations with targeted attributes	M 1-3
2	**Quantify CO_2 sequestration potential of the composite matrices:** Determine sequestration potential for matrices across a range of key process variables	M 2-5
3	**Determine optimal methods of CO_2 recovery and recycle and reuse of composite matrix materials:** Evaluate methods for effective desorption of CO_2, Quantify recovery efficiency, & energy and material requirements	M 3-6
4	**Demonstrate lab scale prototype using live ICE engine systems.** Test select matrix options in lab scale mobile carbon capture system using live engine platforms	M 4-7
5	**Develop process flow diagrams and undertake technoeconomic analysis and Life Cycle Assessment.** Develop process flow diagrams, technology gap analysis, technoeconomic analysis (TEA) and Life Cycle Assessment (LCA)	M 5-9

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Performance metric	Success value	Assessment tool
Stability of CO_2 sequestered within matrix	>90% stability of sequestered CO_2 within matrix	% CO_2 loss from saturated matrix
Size and weight of capture device	>0.6 tons CO_2 per ton capture equipment	kg CO_2 capture per m^3 of matrix
CO_2 capture efficiency of matrix	>2.0 mol CO_2 removed per liter of matrix	mol CO_2 per L matrix
CO_2 capture efficiency of recycled and reused material	>70% CO_2 capture efficiency of recycled vs virgin material	% carbon removal of recycled matrix vs virgin matrix
CO_2 selectivity of matrix	>50% selectivity for CO_2 vs other gases	% selective removal of CO_2 vs other gases in mix
CO_2 recovery during de-sequestration	>90% recovery of sequestered CO_2	% CO_2 recovered vs sorbed CO_2
Matrix component stability	>90% stability of matrix	None to minimal release of solvent from matrix composite
Specific energy for CO_2 capture	>1 kg CO_2/kWh for NG; >2 kg CO_2/kWh for diesel & gasoline engines	Energy and CO_2 capture analysis
Net CO_2 removed per kg fuel used	Kg CO_2 removed per gal fuel used	Overall efficiency of CO_2 removal considering incremental fuel usage due to MCC system
% Energy used for CO_2 capture	<10% decrease in mpg after integration of MCC system	Mileage and fuel usage pre and post integration of MCC system
Carbon footprint of MCC	≤ 0 Net kg CO_2 increment per kg CO_2 sequestered and placed in storage using MCC	Comprehensive LCA – material and energy analysis

Community Benefits

- **Hiring Diverse Personnel**: 2 of 3 program hires identify as minorities
- **Mentorship program**: Formal program initiated to support project personnel with career growth & cleantech careers
- **Promote cleantech careers**: Seminars to Provide seminar session on cleantech solutions to student groups in educational institutions with diverse student bodies in the Maryland area
- **Internships**: Provide internship opportunities to diverse students with interest in | curiosity about cleantech research & development opportunities

Summary & Lessons Learned

- **Project Hiring:** Completed. Start probing ahead of time, Staffing agencies are your best friend
- **Testing:** Just getting underway
- **Commercialization:** Participating in DOE sponsored Phase Shift 1 initiative to support commercialization efforts

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