Department of the Navy SBIR/STTR Transition Program

DISTRIBUTION STATEMENT A. Approved for public release. Distribution is unlimited.
NAVSEA #2019-0574

Topic # N161-040
Advanced Materials for Carbon Dioxide (CO2) Capture
Mosaic Materials, Inc.

WHO

SYSCOM: NAVSEA

Sponsoring Program: PMS 397—Advanced CO2 Removal Unit (ACRU) Program

Transition Target: Columbia Class Program Office (PMS 397)

TPOC:
(215)897-7250

Other transition opportunities:
Carbon dioxide (CO2) removal from deployed, legacy Navy submarines (i.e. Virginia class), NASA vehicles and outposts, International Space Station, hyperbaric chambers, shelter-in-place refuges, point source and atmospheric air CO2 capture.

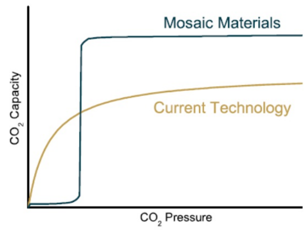

Image Citation: Image courtesy of Mosaic Materials, Inc., Copyright 2019. (left); Naval Sea Systems Command Image (161214-N-LV331-001), available at: https://www.navy.mil/view_imagex.asp?id=229917&t=1

Notes: Mosaic Materials has created a novel solid adsorbent which increases CO2 removal capacity for the current advanced CO2 removal unit (ACRU) deployed by the Navy, but with reduced energy costs freeing up energy for other mission-critical needs. This project complements Mosaic's experience with technology development for upcoming space exploration efforts with NASA. These adsorbent materials have broad applicability across multiple military and commercial enclosed space applications, helping drive down costs for the US Navy.

WHAT

Operational Need and Improvement: For environments utilizing recycled air, carbon dioxide (CO2) respirated by human activity can accumulate to unsafe levels unless actively removed. Currently, submarines utilize both liquid and solid amine-based CO2 scrubbing technologies for cabin conditioning. However, existing systems only harness a fraction of theoretical working capacity. Advancements in adsorbent CO2 cyclic capacity, the rich to lean loading during use, can result in longer duration missions or increased crew sizes while using legacy ACRU systems. Furthermore, legacy systems are energy intensive resulting in a high parasitic load for the CO2 scrubbing system.

Specifications Required: The advanced CO2 adsorbent will display higher cyclic capacities than existing technologies, currently reporting 3 - 5% by weight. During use the material must be able to maintain atmospheric CO2 levels under 0.5% CO2 in submarine operating environments where humidity fluctuates between 30-60% relative humidity and must display high cyclic stability and long useful lifetimes. Furthermore, the material must be made into a suitable form factor enabling drop-in replacement in legacy systems to accelerate adoption and backfitting into the existing submarine fleet.

Technology Developed: Mosaic Materials has developed a new adsorbent: a diamine-appended metal-organic framework (MOF) with high CO2 loading under a variety of humidity and adsorption conditions. The unique adsorption mechanism of diamine-appended MOFs results in "step-shaped" adsorption performance resulting in high cyclic working capacities under milder regeneration conditions when compared to traditional amine-based sorbent technologies. Narrowing process conditions between adsorption and desorption states results in reduced loads on submarine process water and power systems.

Warfighter Value: This technology can improve quality of life of for sailors by maintaining safe operating environments and reducing the complexity of scrubbing system maintenance. Utilizing a solid sorbent-based scrubbing system reduces the complications and hazards associated compared to existing legacy liquid amine scrubbing systems. Higher working capacity systems provide the necessary CO2 removal for safe operation with both a smaller footprint (for future deployments) as well as lower energy usage for legacy and future deployments. Footprint and energy efficiencies free up both space and power for additional equipment, supplies and power supplies for extended missions.

WHEN

Contract Number: N68335-18-C-0728 **Ending on:** September 24, 2019

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Diamine-appended MOFs exhibit high CO2 capacities when removing CO2 from breathable air	N/A	Stable cyclic material performance	3	October 2017
Composite adsorbent experimentally evaluated in prototype unit under 100 process cycles.	Med	Prototype passes	4	September 2019
If Option exercised, continue stability testing with >1000 cycles in mid-scale prototype unit.	Med	Prototype passes	5	September 2020

HOW

Projected Business Model: Mosaic's model to is to manufacture and sell adsorbent material directly to the Government. Initial adsorbent requirements for demonstration testing are being met with existing in-house scale-up manufacturing equipment capable of producing multiple-kg per month. Adsorbent material needs to facilitate fleet-wide deployment levels of multiple-tons per year will be performed, under Mosaic's direction, at external contract manufacturing sites. Mosaic is currently seeking external contract manufacturing partners.

Company Objectives: Mosaic anticipates the SBIR/STTR Transition Program (STP) will broaden our network of connections within the Government and affiliated industrial partners with life support system needs. Short term objectives are to secure a Phase III contract with the DoN to transition fleet-wide technology adoption and to expand our technology to another DoD life support program. Long term goals are to provide packaged life support systems, replacing legacy systems and fully leveraging advantages of Mosaic's advanced life support CO2-selective adsorbents.

Potential Commercial Applications: In addition to alternative aerospace and hydrospace life support applications, this technology can be directly translated to other commercial safety applications designed for human occupancy, like mine refuge chambers and bunkers. The basic principles of Mosaic's adsorbents are relevant to solving key separation challenges faced in other commercial sectors with varying CO2 concentration levels. Point source carbon capture from stack gasses (e.g. coal or natural gas fired power plants) is an example of a widely researched area in need of advanced CO2 removal technologies. Furthermore, applying low-level CO2 removal technology developed under the current SBIR, Mosaic's technology can be applied to direct air capture of CO2 for reducing atmospheric CO2 levels.

Contact: Thomas McDonald, CEO & Co-Founder
tmcdonald@mosaicmaterials.com (303) 578-9567