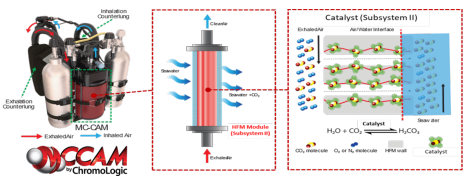


WHO

SYSCOM: ONR
Sponsoring Program: ONR, Undersea Medicine
Transition Target: US Navy diver closed circuit rebreathers
TPOC: Sandra Chapman
sandra.e.chapman2.civ@us.navy.mil



ChromoLogic images

Other Transition Opportunities: CO2 scrubbing system for submarines and the extraction of CO2 from seawater for generating liquid hydrocarbon fuels

Notes: HFM: hollow fiber membrane
 CO2 in exhaled breath is dissolved in seawater through CO2-preferring microchannels in the HFM wall, doped with catalytic nanoparticles forming H2CO3. The CO2-enriched seawater is then dispersed through the porous metal frame of the HFM module, with the surrounding seawater continuously refreshed by ocean currents, diver movement, and diffusion.

WHAT

Operational Need and Improvement: In closed-circuit rebreather (CCR), unused oxygen is recycled after CO2 scrubbing and O2 enrichment to extend dive duration. While O2 cylinders support 10-hour dives, typical commercial CCR last 2-3 hours, with soda lime granules capturing exhaled CO2. CO2 levels rise rapidly when 60-80% of the soda lime is consumed. A next-generation CO2 scrubbing module is needed to maintain safe CO2 levels and extend endurance to 10 hours with 60% of standard CO2 scrubber size.

Specifications Required: A passively designed system is needed to scrub CO2 at a rate matching the metabolic rates of an active diver for missions lasting up to 10 hours, while adhering to current size and power consumption constraints.

Technology Developed: Unlike typical chemical methods, MC-CAM uses a membrane contactor process enhanced by a catalyst to convert surrounding seawater into an infinite CO2 absorbent. CO2 from exhaled breath is dissolved in seawater and catalytically converted to carbonic acid. The CO2-enriched seawater is then dispersed and continuously refreshed by ocean currents, diver movement, and diffusion.

Warfighter Value: Chronic exposure to soda lime dust can lead to airway inflammation and small airway disease in divers. Additionally, water leaks into rebreathers can cause a 'caustic cocktail' by dissolving alkaline substances into the breathing loop. With no chemicals involved in CO2 removal, MC-CAM is safe and eliminates these risks entirely.

WHEN

Contract Number: N68335-24-C-0041 **Ending on:** Jan 09, 2026

Milestone	Risk Level	Measure of Success	Ending TRL	Date
Improve mass transfer coefficient (Koverall) by adjusting average pore size	Medium	Koverall meets the requirement	3	3rd QTR FY24
Evaluate nanozyme and dope catalytic nanoparticles in HFM for a further improvement in Koverall	High	Koverall meets the requirements	3	1st QTR FY25
Scale up HFM fabrication	Low	Obtain sufficient HFMs for prototype preparation	4	3rd QTR FY25
Prepare small prototypes for in-house evaluation on MC-CAM	Medium	pass the evaluation tests	6	4th QTR FY25
Prepare full-size prototypes for a third-part evaluation on MC-CAM	Medium	pass the third-party evaluation tests	7	1st QTR FY26

HOW

Projected Business Model: The business model involves collaborating with U.S. Navy end users to develop a prototype for direct integration into existing SCUBA CRRs. We target civilian underwater operations and CO2 capture industries for MC-CAM application with minimal modification to facilitate market entry. We plan system optimizations tailored to each market segment, producing demonstration systems with functional specifications, pricing estimates, and presenting them to potential customers and commercial partners.

Company Objectives: The company aims to produce hardware prototypes based on Phase I efforts, verify their performance, and outline integration into SCUBA systems. By Phase III, a prototype will be ready for Government testing. Success with MC-CAM will create opportunities for small businesses to supply compact CO2 removal modules to various Government agencies involved in underwater operations and waste gas treatment.

Potential Commercial Applications: Integrated with current diving systems, the MC-CAM system has diverse civilian applications, including leisure diving, ship cleaning, underwater construction, rescue, education, journalism, and scientific research. The scaled-up MC-CAM HFM module can also remove CO2 from flue gases using seawater and limestone, converting it to calcium bicarbonate. This process increases seawater alkalinity, protecting marine life from acidification.