

Title: CO₂ capture using enzyme based membrane reactors.

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Carbon dioxide (CO₂) must be removed from a wide variety of feed gases over a considerable range of concentrations and pressures – oxygen environment <1%, <1atm; air <1%, 1atm; flue gas 5-20%, 1atm; landfill gas ~25%, 1atm; and natural gas 5-75%, 5-20atm. Numerous physical and chemical methods have been developed and used in this pursuit. They all have limitations in one or more of the following areas: specific applicability, permeance, selectivity, energy requirements, labor and materials support requirements, toxicity, environmental pollution, safety, longevity, or cost.

Working with NASA we have developed an enzyme catalyzed contained liquid membrane reactor suitable for cleansing the respiratory gas of astronauts whether in the spacesuit or the space station. This system is designed to extract CO₂ from concentrations as low as 0.03% and enrich it to concentrations in excess of 95%, dry gas, in a single step. Current research has readily demonstrated enriched concentrations of greater than 56% using a relatively simple design. The feed gas is either oxygen at 0.4atm, 23°C, 60%RH (spacesuit) or air at 1atm, 23°C, 60%RH (space station). NASA's objective is to have a solution that minimizes mass, volume, consumables, maintenance, and energy while maximizing safety, stability, reliability and performance characteristics. For the spacesuit application they want a selectivity vs. O₂ in excess of 3,000:1 while for the space station they want a permeate concentration in excess of 95% for secondary processing. We have achieved many of these objectives – permeance on the order of $1 \cdot 10^{-7}$ moles CO₂ m⁻² s⁻¹ Pa⁻¹ and the selectivity vs. N₂ on the order of 1800:1. We are moving along to attain the rest. This technology is immediately relevant to CO₂ capture from air.

Working with DOE we have focused on using the enzyme catalyzed contained liquid membrane reactor suitable for extracting CO₂ from flue gas streams and from natural gas streams. Using this technology, we have successfully demonstrated the ability to capture CO₂ from streams containing 5%, 10% or 20% CO₂ and to concentrate it to 95%, 96% and 97%, respectively, in a single pass. The permeance is on the order of $1 \cdot 10^{-7}$ moles CO₂ m⁻² s⁻¹ Pa⁻¹ and the selectivity vs. N₂ on the order of 150:1. The separation from a natural gas feed is also appreciable.