Membrane Carbonation for 100% Efficient Delivery of CO_2 from Industrial Gases

Bruce E. Rittmann[†§] (PI)

School of Sustainable Engineering and the Built Environment[†], Biodesign Institute[§], Arizona State University, Tempe Arizona 85287, USA.

Abstract. Increasing the CO_2 concentration in gas supplied to a microalgae growth system can improve its productivity many fold over using atmospheric air. Many industrial gases contain concentrated CO_2, but with significantly different CO_2 concentrations (i.e, from 10% to 80%) and accompanying gases (e.g., N_2, O_2, CH_4, and H_2S). Traditional sparging methods for delivering CO_2 are < 40% efficient. Because collecting, cleaning, and distributing the CO_2-bearing gases incur costs, CO_2 delivery to the microalgae needs to be nearly 100% efficient, and this need is amplified with the CO_2 is from a fossil source.

We propose to deliver CO_2 from the range of industrial gases using Membrane Carbonation (MC), in which CO_2 diffuses through the walls of non-porous gas-transfer membranes on demand according to the rate of photosynthesis. Gas delivery is via diffusion through a membrane, which means that CO_2 delivery can achieve ≥ 90% efficiency at a cost of ~$3/ton (**Figure A**).

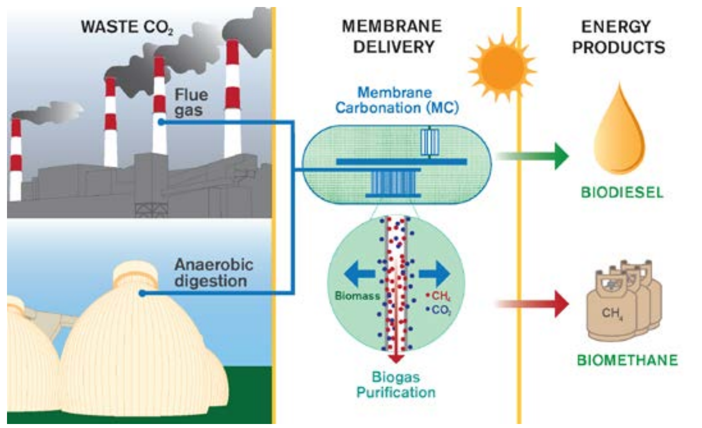

Figure A. Schematic illustrating how membrane carbonation (MC) delivers CO_2 with ≥ 90% efficiency to increase the value of energy outputs.

We will develop optimized design and operation strategies so that MC can deliver CO_2 with ≥ 90% efficiency and at rates that support microalgae productivity high enough to make biofuels from microalgae economically attractive. We will do this for the CO_2 concentrations found in the range of industrial sources. The technical strategy involves determining the optimal operation of a bleed valve at the membrane's outlet. The small bleed flow prevents the buildup of inert gases, but without significant loss of CO_2. For biogas from anaerobic digesters and landfills, we also will evaluate how to enrich the exit gas in CH_4 from 65% to ≥ 97% biomethane, which has much higher-value uses than the original biogas. Gas-transfer modeling, techno-economic analysis, and life-cycle assessment will be conducted throughout the project to guide the experimental research, which will be carried out using *Scenedesmus* in laboratory-scale photobioreactors and small outdoor raceway ponds. These modeling techniques also will be used to generate optimal design and operating strategies for large-scale implementation of MC.

The project's ultimate objective is to develop and demonstrate strategies for using MC to deliver CO_2 from the array of industrial sources. The strategies will provide ≥ 90% efficiency for CO_2 delivery and precise pH control at ~$3/ton with savings of $88/ton over sparging and major life-cycle benefits. For biogas, MC will provide an added benefit of upgrading the biogas to biomethane.