Continuous Hydrogen Peroxide Production in Microbial Electrochemical Cells

Michelle N. Young*, Dr. Sudeep C. Popat, Dr. Bruce E. Rittmann, and Dr. César I. Torres
Swette Center for Environmental Biotechnology, The Biodesign Institute at Arizona State University, Tempe, AZ 85044

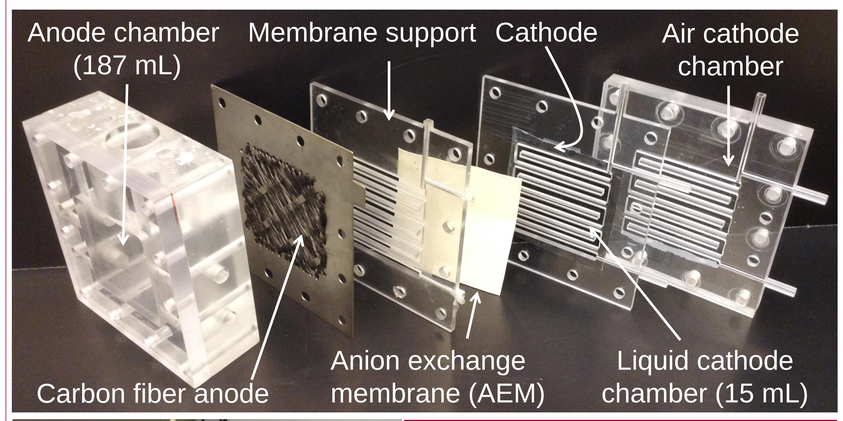
Can we produce hydrogen peroxide more sustainably?

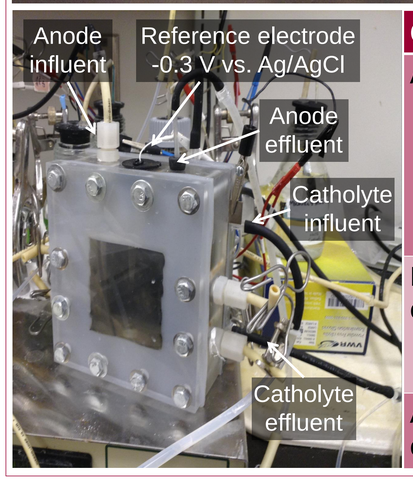
We demonstrate **continuous hydrogen peroxide (H_2O_2) production** in a dual-chamber **microbial electrochemical cell (MEC)** as high as 0.22 wt% and at an average concentration of 0.09 wt% with <0.26 W-hr/g H_2O_2 power input. Buffering electrolytes provide no performance advantages vs. a salt solution.

Background

More than 90% of the world's H_2O_2 is produced using the energy-intensive anthraquinone process. H_2O_2 can be produced sustainably in MECs. Other researchers have produced H_2O_2 in MECs under batch conditions at either high concentrations (0.13 wt%) with high power input (0.93 W-hr/gH_2O_2) or low concentrations (0.007 wt%) with some power production (20 W-hr/gH_2O_2).

A MEC with a continuous-flow cathode





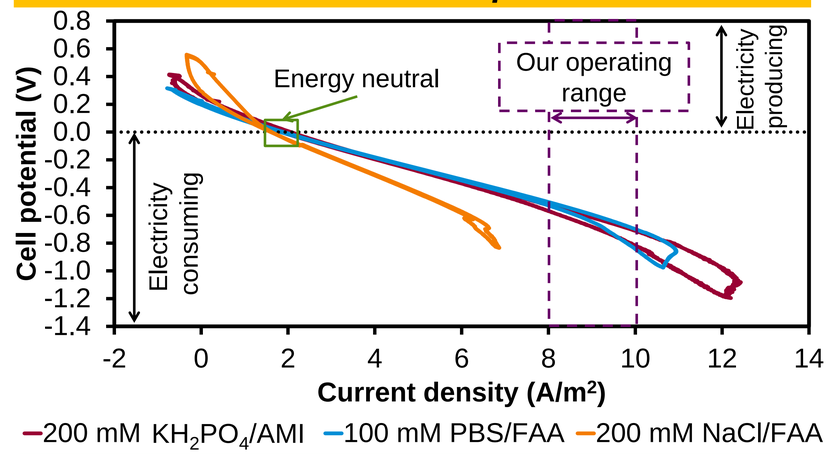
Operational conditions

Anode	• 3.5 m of carbon fiber weaved on a titanium plate • 100 mM acetate media • Lab inoculum
Liquid cathode	• Vulcan carbon catalyst with Nafion binder • 4 hr HRT
Air cathode	• 30 cm^3/min air flow

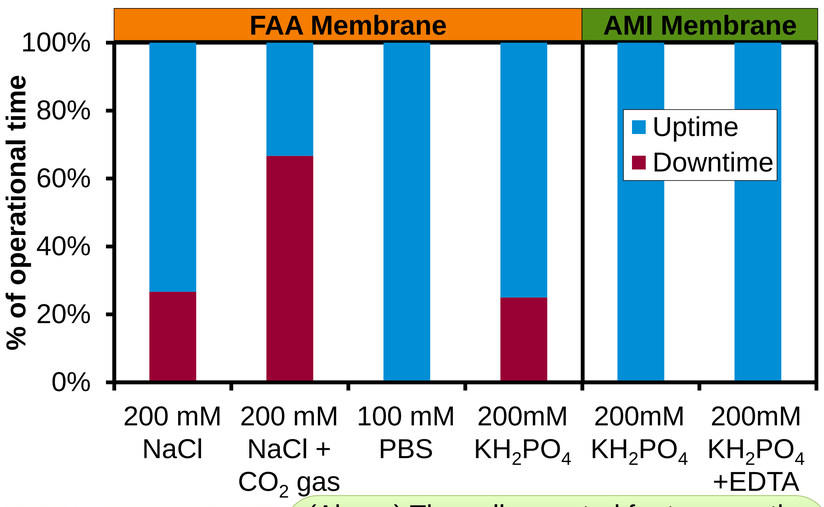
Conditions evaluated

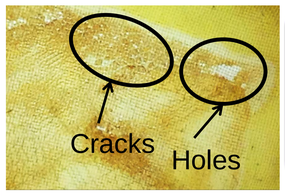
Different membranes	• Fumasep® FAA AEM • Membranes International, Inc. AMI-7001 AEM
Different catholytes	• 200 mM NaCl (~ pH 8) • 200 mM NaCl buffered using air/CO_2 diffusion through the cathode (~ pH 6.5) • 85 mM Na_2HPO_4 +15 mM KH_2PO_4 (100 mM PBS) (~ pH 7) • 200 mM KH_2PO_4 (~ pH 4.3) • 200 mM KH_2PO_4 + 2mM EDTA (~ pH 4.0)

Operated as a MEC, membrane selection proves critical for continuous performance



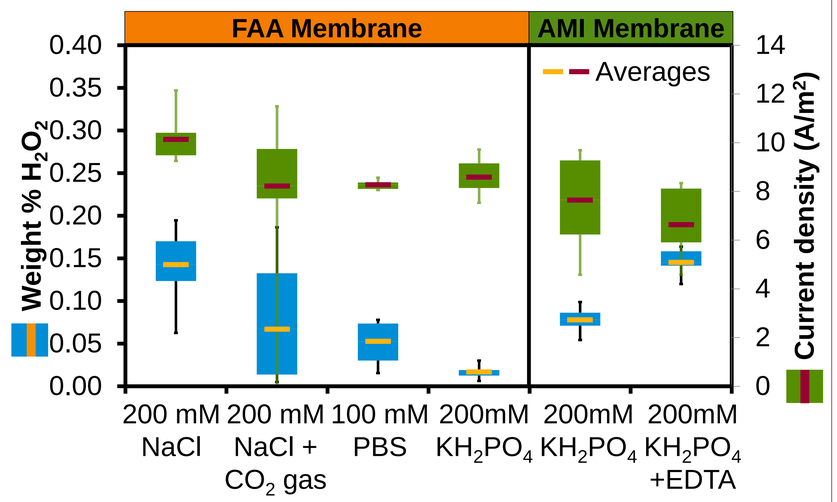
The catholyte/membrane combinations have little effect on the potential losses in the cell. Our MEC operated at 8-10 A/m^2, requiring a potential input of 0.5-0.7 V.





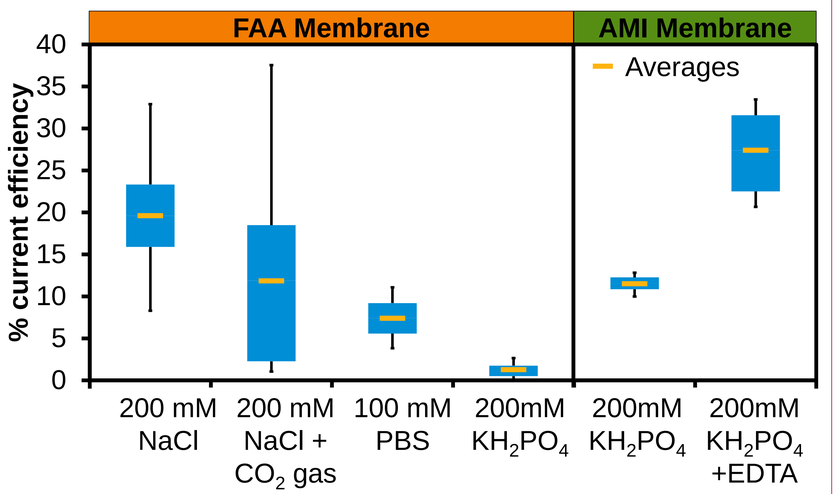
(Above) The cell operated for two months total. Continuous operations are achieved with the AMI membrane, not the FAA. The FAA membrane experienced several ruptures due to H_2O_2 deteriorating of the membrane (left).

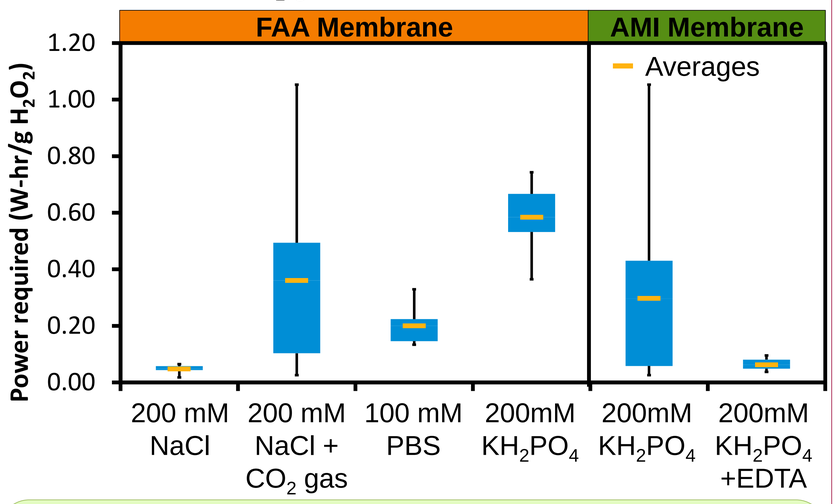
Our MEC continuously produced more H_2O_2…



Cathode pH ranged between 10.5 -12.5 regardless of electrolyte. Acidic and buffering electrolytes did not improve H_2O_2 production.

with little power input.





When buffers are present, the MEC experiences decreased current efficiencies and increased power input, in part due to increased cell death from membrane ruptures and peroxide-based byproduct production. However, EDTA improves current and power efficiencies.

Acknowledgements

Funding is provided by the U.S. Department of Defense's Strategic Environmental Research and Development Program (SERDP) grant number ER-2239.

Presenting author

Michelle Young, Ph.D. student in Environmental Engineering
Email: themnyoung@gmail.com
Website: mnyoung.com