Microbial Electrolysis Cells

Generation of Hydrogen gas from different types of bacteria

Kaalindi Misra, Jeremy Chignell and Dr. Hong Liu

Introduction:

Problems:

•CO_2 emissions from fossil fuels cause abnormal climate changes

•80% of global hydrogen production relies on reformation of natural gas

•Can we produce H_2 gas, a likely candidate for renewable future fuel, with high efficiency from renewable sources?

Solution:

•Microbial Electrolysis Cell (MEC) is an electrochemical system in which organic substrates are degraded by microbial catalysis to produce hydrogen gas

•MEC's are divided into 2 compartments—an anode and cathode, separated by a semi-permeable ion exchange membrane. The reactions are as follows:

Anode: $C_2H_4O_2 + 2H_2O \rightarrow 2CO_2 + 8H^+ + 8e^-$

Cathode: $8H^+ + 8e^- \rightarrow 4H_2$

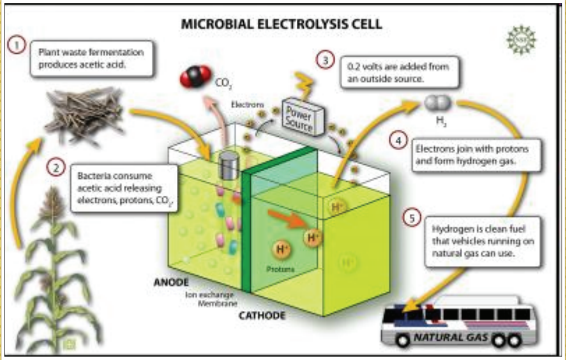

Fig 1: This is an illustration of how a Microbial Electrolysis Cell works. Credit:Zina Deretsky, National Science Foundation

Provided information:

• Species A gives highest hydrogen yield in sucrose media

• Species B was observed to form syntrophic relationships

Hypothesis:

• Co-culture species A & B will produce more hydrogen gas in MEC in sucrose media than both the pure culture of species A and species B

Method:

- Inoculate on agar plate
- Prepare Modified Geobacter Medium (MGM) with sucrose as a substrate
- Isolate the bacterial colony of species A and species B
- Transfer to small anaerobic tubes and incubate 24 hours at 32°C.
- Transfer the MGM + Sucrose media to three anaerobic MEC's for species A, species B and species A+B
- Connect them to voltammeter for baseline data
- Inoculate the bacterial species in their respective MEC reactors
- Record increase in current generation
- Measure proportion of H_2 gas in reactor headspace samples with gas chromatograph every 24 hours

Results:

•After analyzing the data, species A in MEC reactors produced more hydrogen gas than any other species

•Species B in MEC reactors produced less hydrogen gas in comparison to its fermentation control

•The performance of co-culture species A & B in sucrose media was shown to be one mL less than species A

•Production of carbon-dioxide gas confirms that the species are respiring in MEC reactors

	Species A	Species B	Species AB
H2	4.059	1.969	3.59
CH4	0	0	0
CO2	2.885	2.236	2.66
Total	11.918	11.537	11.821

Table 1: Volume (mL) of different gases produced in MEC for Species A, B and AB

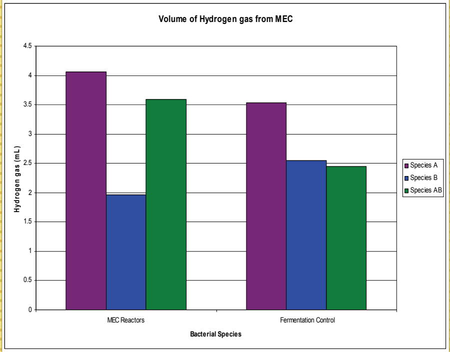

Fig 2: Graphical representation of hydrogen gas produced in MEC and Fermentation controls from species A, B and AB

Conclusion:

•The data suggests that the pure culture of species A produces more hydrogen gas than the co-culture of species A & B and pure culture of species B on sucrose media

• In this study, species A and co-culture of species A & B prefer to respire on sucrose media in a MEC reactor

• Whereas, pure culture of species B ferments rather than respiring on sucrose media in a MEC reactor

• Species B seems to make an inhibitory effect on species A's hydrogen gas production when used in a syntrophic relationship on sucrose media

Future Work:

• To find the Columbic efficiency for each MEC reactor which shows the efficiency of carbon use by the bacteria

• To determine the different compounds present in the gas by using GC-MS so that we would know which metabolic reactions are taking place in MEC reactors

Acknowledgements

This research was conducted in Dr. Hong Liu's lab and sponsored by Surface Biosphere Initiative (SBI).