The Effects of Cathode Variation on Hydrogen Production in Microbial Electrolysis Cells

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Introduction The cathode is thought to be the limiting factor of hydrogen production in MECs. To test this theory two factors influencing the MECs performance were explored: cathode to anode ratios and use of nickel alloy catalysts at the cathode. The hydrogen yield of an MEC can be affected by the size of the cathode. When the protons and electrons produced by the bacteria have more surface area at the cathode to combine on more hydrogen will be produced. Voltage measured should directly relate to the amount of hydrogen produced. The second set of experiments uses nickel alloys (ie: NiMo, NiW) as an alternative cathodic catalyst to platinum (Pt). Pt is commonly used as a cathodic catalyst in MFCs/MECs, but it is expensive and difficult to acquire. These nickel alloys are much more economical and readily available.

Hypothesis - **(1)** A larger cathode to anode ratio will produce more hydrogen. **(2)** Ni-alloy catalysts will function well at neutral pH and in complex bacterial medium solution in MECs. **(3)** Electrodeposition of Ni-alloy on 3-dimentional carbon-cloth will increase the surface area of catalysts and then increase the hydrogen production rate.

Experiment #1 – Cathode to Anode Ratio's Affect on Hydrogen Production

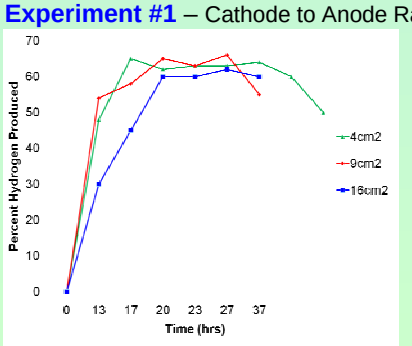

Fig. 1 - Measurements of the percentage of Hydrogen produced (taken with a gas chromatographer) using various sizes of cathodes to 9cm^2 anodes. The system was exposed to air between each run to inhibit the growth of methanogens. The 4cm^2, 9cm^2 and 16cm^2 cathodes were run consecutively.

Experimental Design - MEC

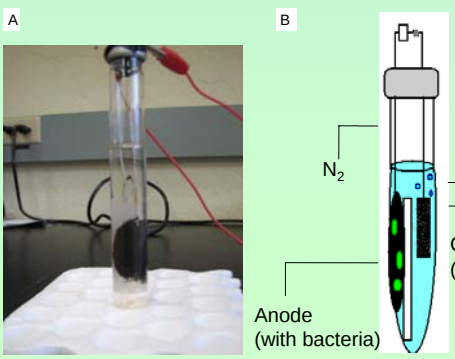

Fig. 2 - Microbial fuel cell photo (A) and diagram (B).

Experiment #2 - Nickel-Alloys vs. Platinum as the Cathodic Catalyst

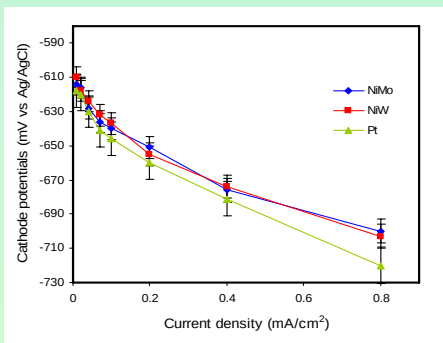

Fig. 5 - Cathode potentials

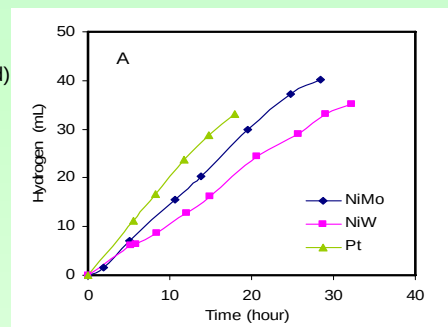

Fig. 6 - H_2 production at 0.6 V

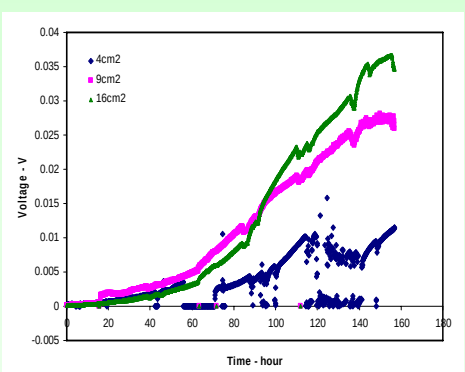

Fig. 3 - 500 mL bottle MECs with various cathode areas. Inoculated with10 mL of water taken from an MFC. New anodes were used to allow the bacteria to grow onto each anode at the same rate.

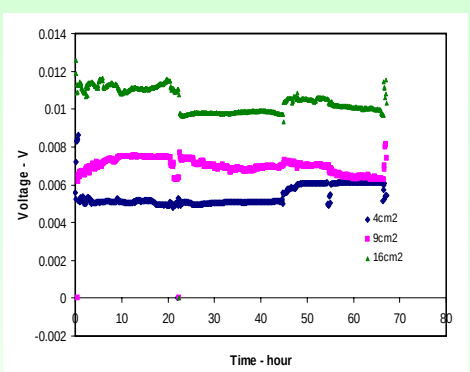

Fig. 4 -Tube MECs with various cathode area. All anodes and cathodes were boiled at 100°C for 5 minutes since there were huge amount of CH4 present in previous batch, and then put back into MECs, no new inoculation.

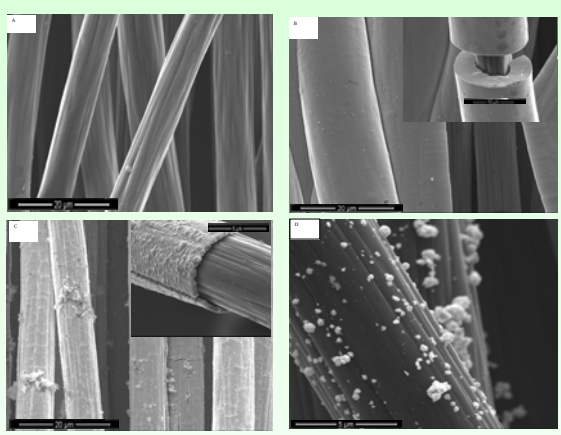

Fig. 7- SEM for Ni-alloy on carbon cloth.
(A) Plain cloth, (B) NiMo, (C) NiW, (D) Pt

Conclusions -

1. The 16cm^2 cathode can achieve a higher voltage than the smaller cathodes, which theoretically should directly relate to the amount of hydrogen produced.
2. The measured relationship of hydrogen yield to cathode size is still being tested.
3. By electrodepositing NiMo and NiW onto carbon cloth, MECs with these cathodes could achieve performances comparable to those with Pt cathode.
4. Carbon cloth can provide a three-dimensional surface for electrodepostion of non-precious metal catalysts and result in a high specific surface area of catalytic coatings.

References:

1.Hu et al., 2008, Water Research 42, 4172-4178;

2.Oh S, Min B, Logan BE., 2004, ES&T 38, 4900-4904;

3.Navarro-Flores et al., 2005, J of Molecular Catalysis A: Chemical 226, 179-197