Optimization of Mass Transport within Direct Formic Acid Fuel Cell Catalyst Layer via Pore Formers

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Introduction

Why Direct Formic Acid Fuel Cells?

- Efficient Portable Power
- Low Overpotential
- High Power Density
- Formic Acid is sustainable

ANODE

$HCOOH \rightarrow CO_2 + 2H^+ + 2e^-$

CATHODE

$\frac{1}{2} O_2 + 2H^+ + 2e^- \rightarrow H_2O$

OVERALL REACTION

$HCOOH + ½\ O_2 \rightarrow CO_2 + H_2O$

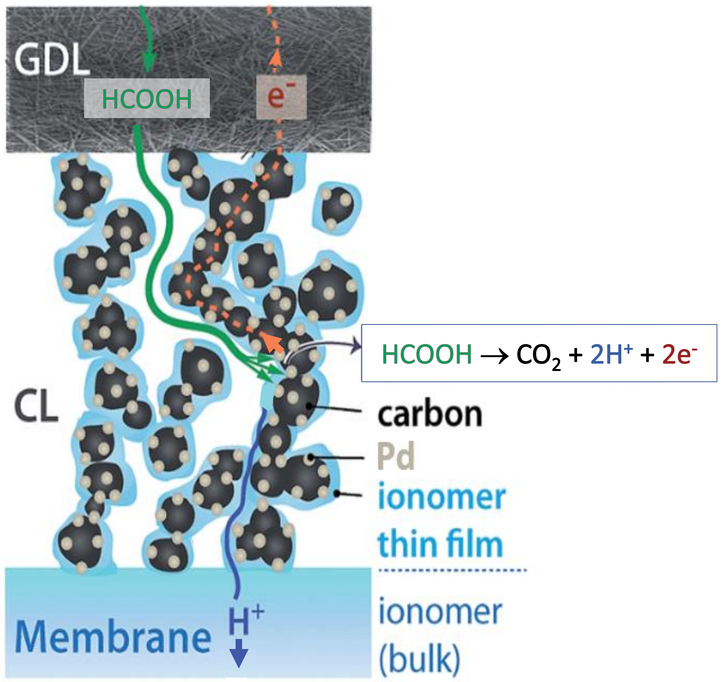

Figure 1. Mass transport of reactants and products through the catalyst layer[1] (Modified). Increasing pore size will increase mass transport through the catalyst layer.

Problem Statement

Mass Transport Limitations within the Catalyst Layer

- Mass Transport limits reaction kinetics
  - Decreases overall cell performance

Hypothesis:

Pore-former

- Magnesium oxide (MgO) forms ~100 nm pores within catalyst layer
- High-porosity catalyst layer optimizes mass transport
  - Increases overall cell performance

Results

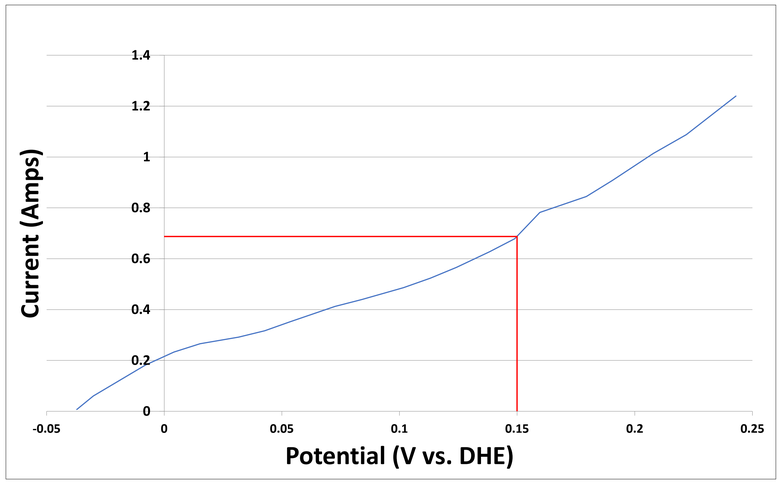

Figure 2. Linear sweep voltammetry of catalyst layer containing 20% MgO. This test monitors cell performance and catalytic activity. Current at 0.15 V indicated by red lines.

Linear Sweep Voltammetry

- Measured versus Dynamic Hydrogen Electrode (DHE) as the reference electrode
- Monitor cell performance at ~0.15 V
  - 0.15 V is a standard operating voltage
- High catalytic activity at 0.15 V
  - ~0.68 Amps at 0.15 V

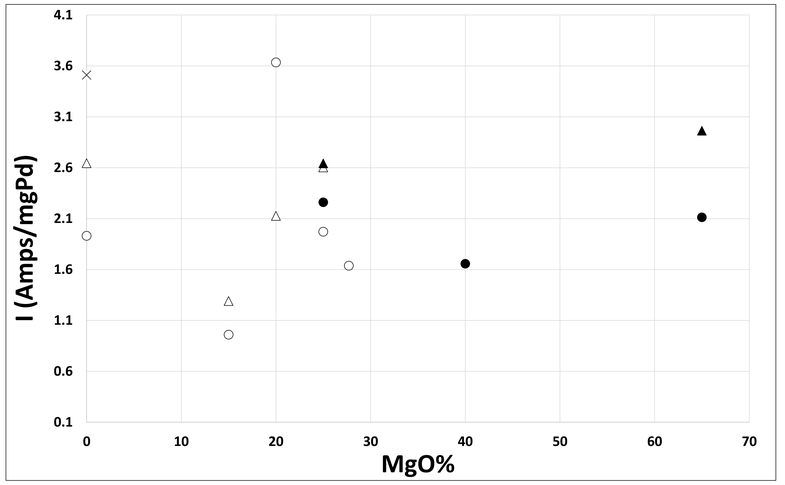

Figure 3. Linear sweep voltammetry data of current produced at 0.15 V vs. MgO weight %. The current is normalized with the catalyst loading on the anode. Pre (open-shape) and Post (closed) Nafion (ionomer) MgO additions are shown.

- Higher current produced at ~20% MgO
  - Higher catalytic activity due to higher mass transport
  - Mass transport may be optimized at ~20% MgO

Conclusions

- Magnesium oxide pore-former increases catalyst layer mass transport
  - Increased electrochemical surface area and catalytic activity

Future Work:

- Continue testing different catalysts with different MgO %.

References and Acknowledgments

1. Weber, A. Z.; A. Kusoglu, J. Mater. Chem. A., **2014**, 2, 17207

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