ENHANCING DEVICE DURABILITY OF PROTON EXCHANGE MEMBRANE FUEL CELLS VIA POLYDOPAMINE COATING

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WHY PROTON EXCHANGE MEMBRANE (PEM) FUEL CELL?

Clean energy

Easily obtainable hydrogen and oxygen/air fuel

Water is the only byproduct

Multiple uses
  - Large scale industry
  - Small scale mobile, like automobiles
Key components:
Anode and Cathode
Gas Diffusion Layer (GDL), carbon paper
Proton conductive membrane, nafion 212
Precious metal catalyst, platinum
Membrane Electrode Assembly (MEA)
2 GDLs, catalyst, and membrane
PEM FUEL CELL PROBLEMS

High cost
- Precious metal catalysts, most commonly platinum on carbon black
  - High catalyst loading increases performance AND cost

Low durability
- Low catalyst loading causes amalgamation due to increased surface energy
  - Catalyst amalgamation decreases performance by decreasing active catalyst sites
- Fuel crossover degrades membrane
  - This causes increased crossover and further degradation
WHY DOPAMINE?

Increased Durability
- The dopamine acts as an adhesive layer “glue” binding the MEA and decreasing mechanical stress
- Blocked pores decrease fuel crossover
  - Catechol functional groups on dopamine still allow proton permeability
  - Dopamine blocks access to the membrane backbone, lessening the effects of fuel crossover

Decreased Cost
- The “glue” binds catalyst in place, decreasing amalgamation
  - particularly useful with lower catalyst loading
Figure 1: Scanning electron microscopy images (a) and (c) show the new and after lifetime test pictures of a standard MEA, note the large crack. Images (b) and (d) show before and after images for a dopamine treated MEA. The delamination is noticeably less in dopamine treated MEA.
MEA FABRICATION PROCEDURE

Membrane hydration and Dopamine Treatment
Ultrasonic spray catalyst application
Heat pressing at 135°C and 80psi – causes temperature damage, binds MEA
MEA TESTING

Linear sweep voltammetry (LSV) tests
Cyclic voltammetry (CV) tests
Performance tests
Long term durability test

Pre-break in

Standard tests

High temp tests
- High breakdown
LSV RESULTS

LSV at 120/90/90C

Current (mA/cm²) vs Voltage (V)

- MEA 002 std
- MEA 003 w/ dopamine
CV RESULTS

CV at 25/25/25C postbreak-in

Current (mA/cm²) vs. Voltage (V)

- MEA 002 std
- MEA 003 w/ dopamine
PERFORMANCE CURVE RESULTS

Performance Curve at 80/80/73C 1.5atm backpressure

OCV
MEA002: 1.0013V
MEA003: .98165V
LONG TERM TEST RESULTS

Constant Current at 100/90/90C 1.5atm backpressure

Voltage

Time hr

MEA 002 std
MEA 003 w/ dopamine
FUTURE TESTS

Improve dopamine application
Improve catalyst loading
- Decrease loading
Mo2C co-catalyst incorporation
CONCLUSION

Dopamine improves all of the key problems facing PEM fuel cells

- **Improved durability**
  - “Glue” reduces stress
  - Decreases amalgamation
  - Reduces fuel crossover

- **Decreased cost**
  - Reduced amalgamation allows for lower loading

Preliminary tests show extremely promising results
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REFERENCES


