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

BRIDGER MARTIN
CHEMICAL ENGINEERING
ADVISING PROFESSOR: DONGMEI LI

WHY PROTON EXCHANGE MEMBRANE (PEM) FUEL CELL?

Clean energy

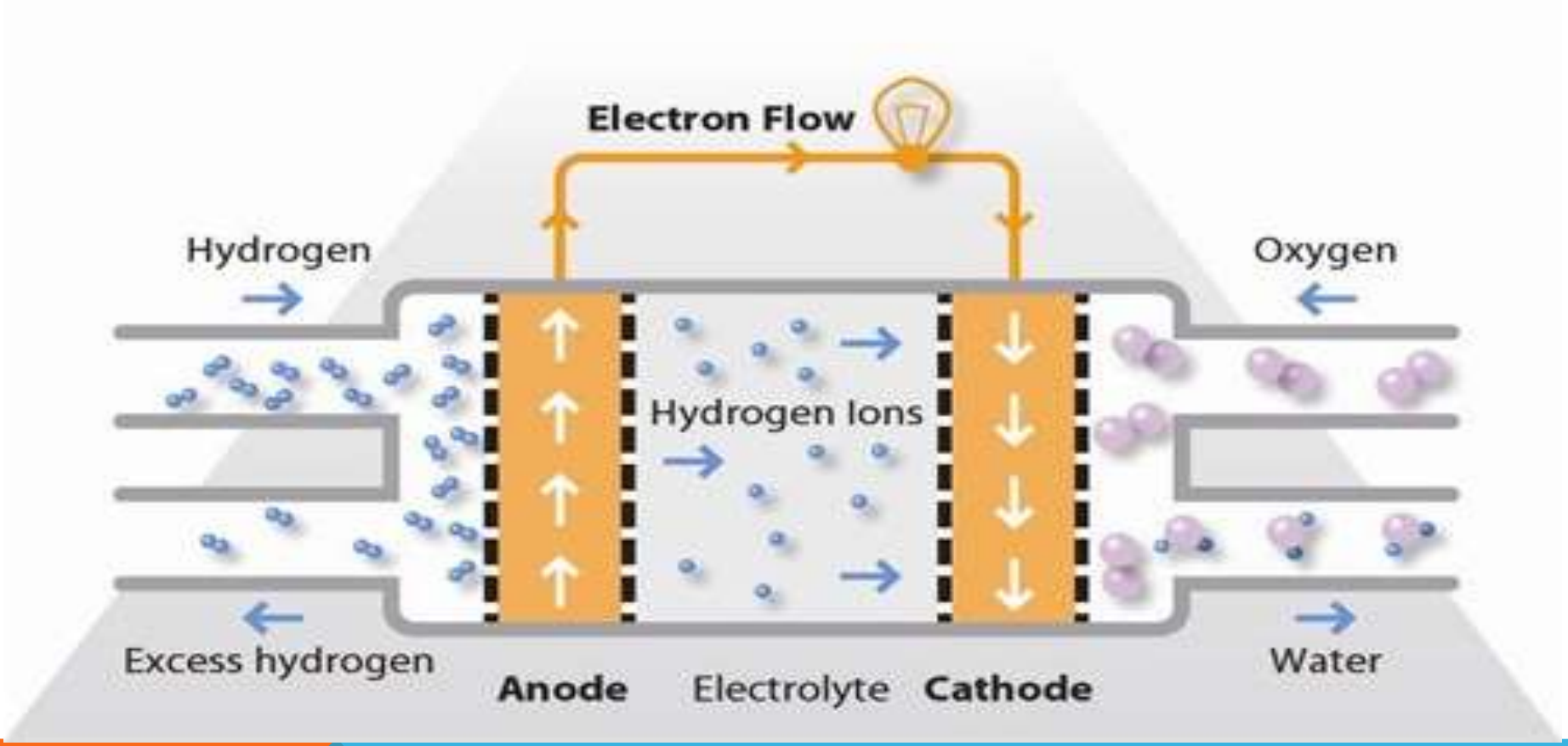
Easily obtainable hydrogen and oxygen/air fuel

Water is the only byproduct

Multiple uses

- Large scale industry
- Small scale mobile, like automobiles

PROTON EXCHANGE MEMBRANE (PEM) FUEL CELLS



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

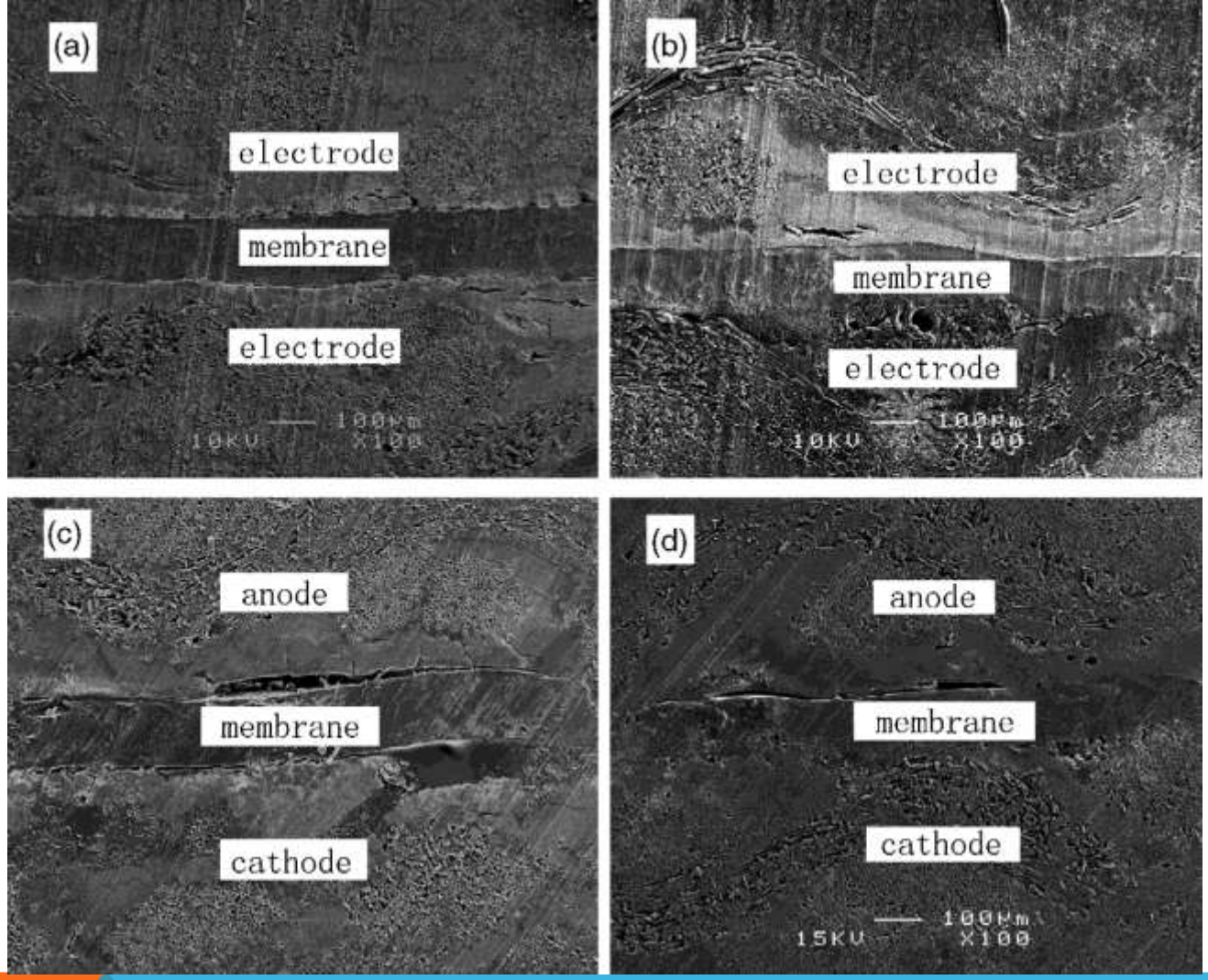


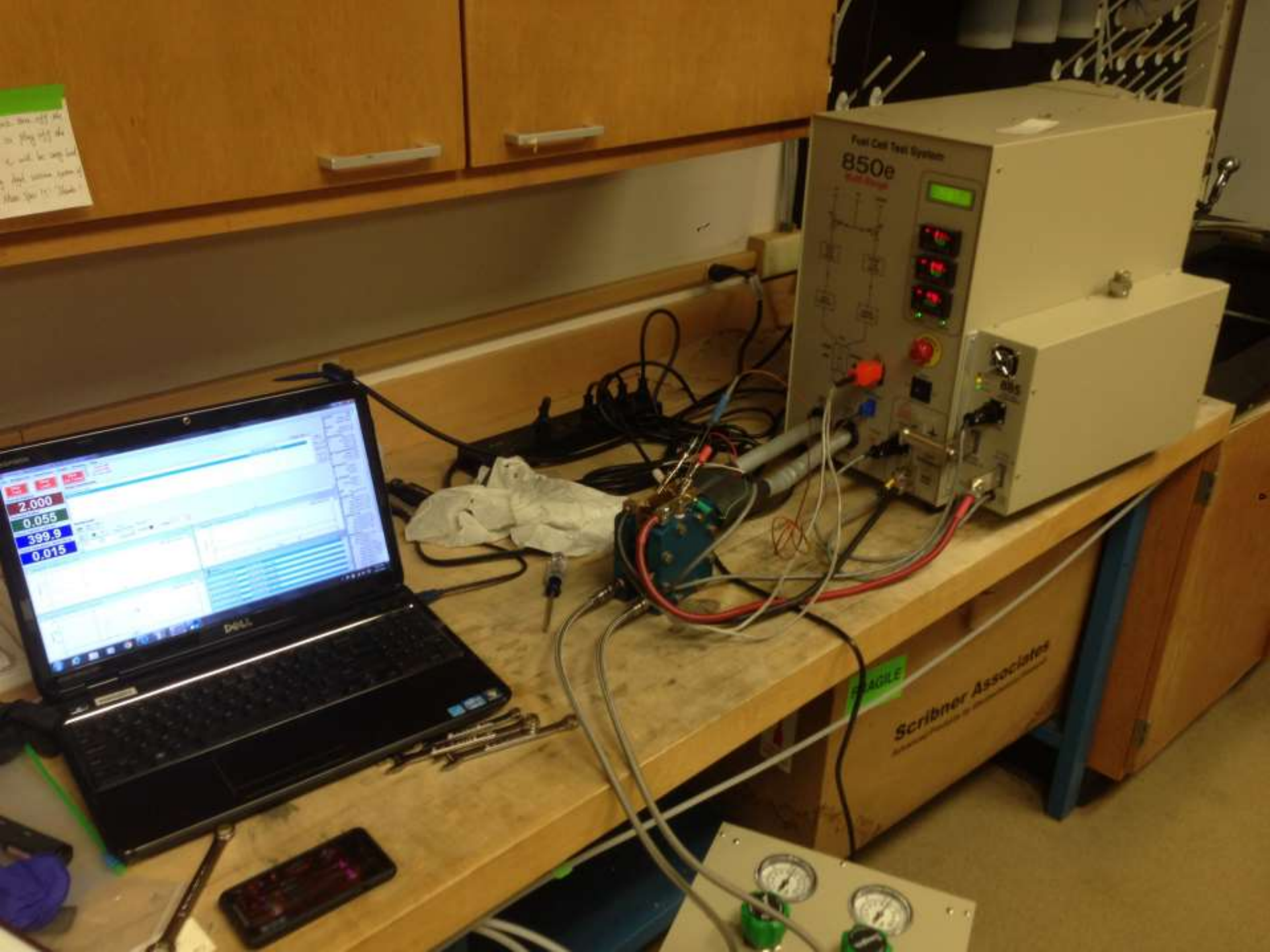
Figure 1: Scanning electron microscopy images (a) and (c) show the new and after lifetime test pictures of a standard MEA, note the large crack. Images (b) and (d) show before and after images for a dopamine treated MEA. The delamination is noticeably less in dopamine treated MEA.

MEA FABRICATION PROCEDURE

Membrane hydration and Dopamine Treatment

Ultrasonic spray catalyst application

Heat pressing at 135C and 80psi – causes temperature damage, binds MEA


Fuel Cell Test System
850e
2.000
0.055
399.9
0.015
DELL
Scribner Associates

MEA TESTING

Linear sweep voltammetry (LSV) tests

Cyclic voltammetry (CV) tests

Performance tests

Long term durability test

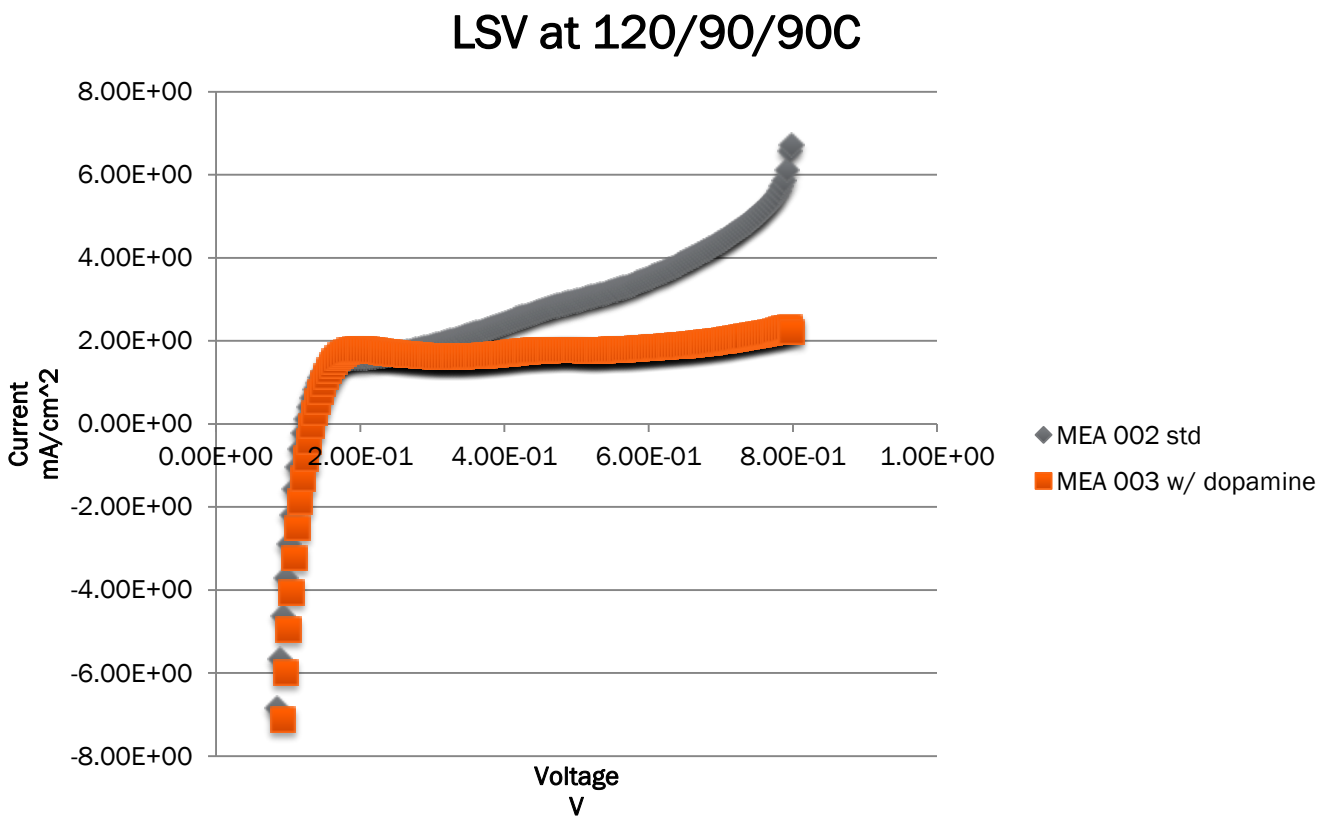
Pre-break in

Standard tests

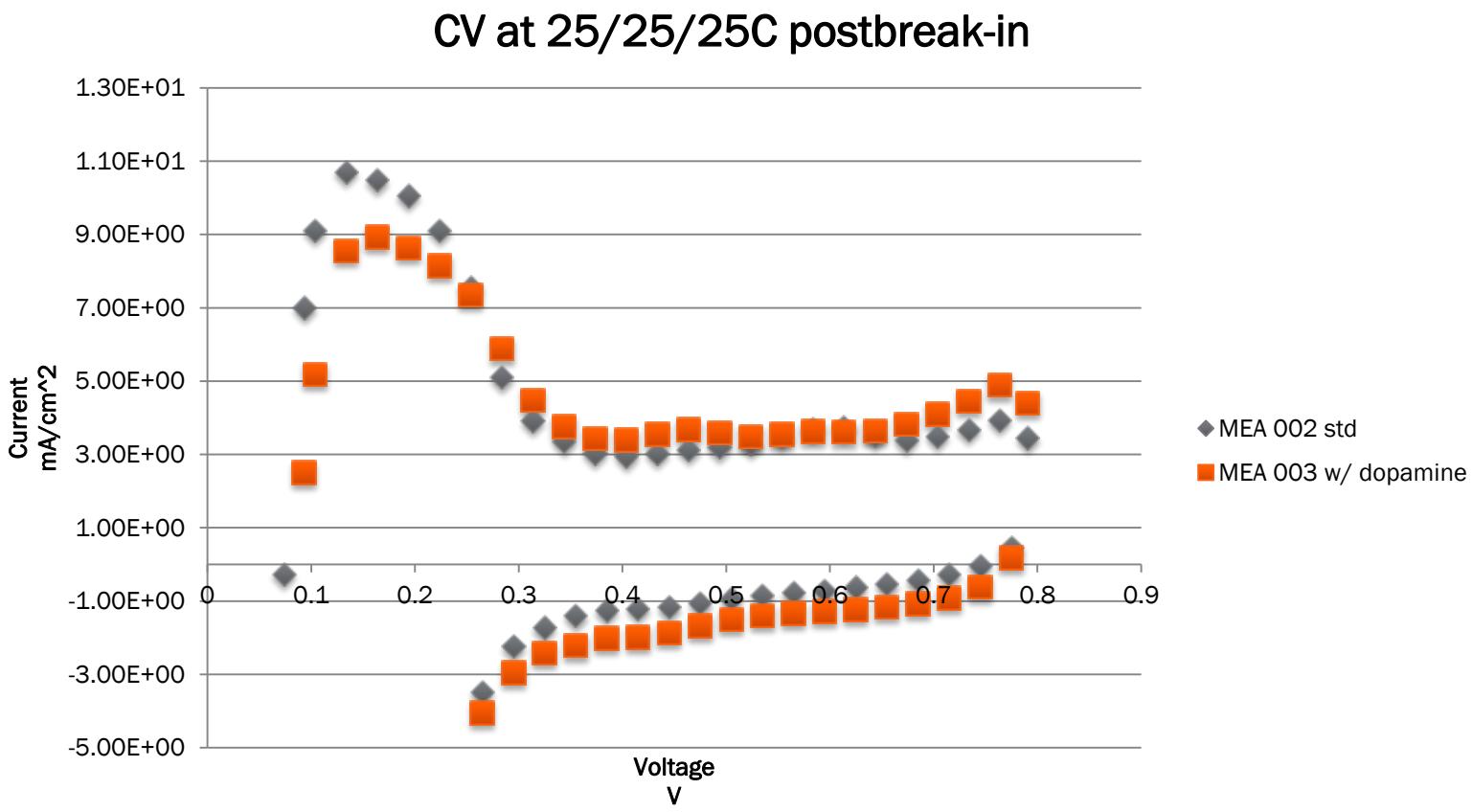
High temp tests

- High breakdown

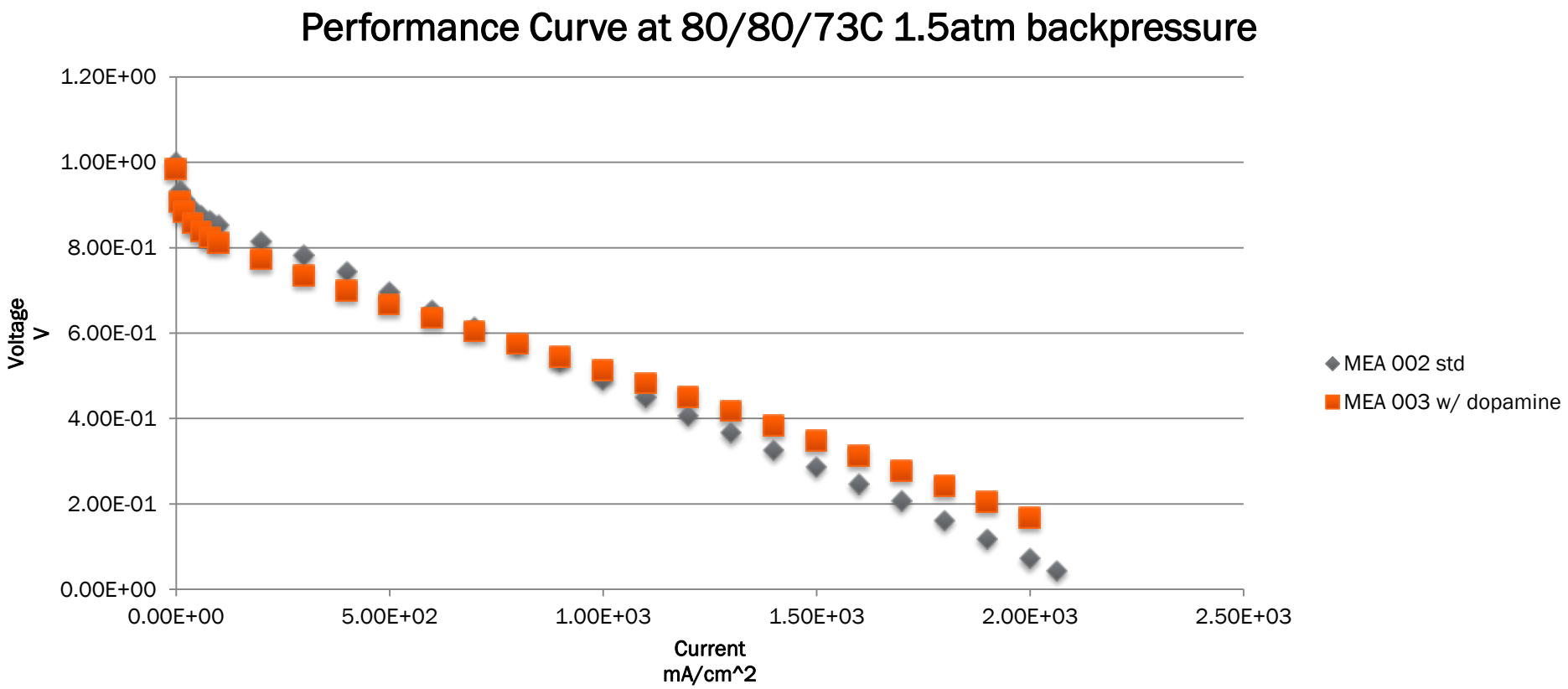
LSV RESULTS


LSV at 120/90/90C
8.00E+00
6.00E+00
4.00E+00
2.00E+00
0.00E+00
-2.00E+00
-4.00E+00
-6.00E+00
-8.00E+00
Current mA/cm^2
0.00E+00
2.00E-01
4.00E-01
6.00E-01
8.00E-01
1.00E+00
Voltage V
MEA 002 std
MEA 003 w/ dopamine

CV RESULTS


CV at 25/25/25C postbreak-in
1.30E+01
1.10E+01
9.00E+00
7.00E+00
5.00E+00
3.00E+00
1.00E+00
-1.00E+00
-3.00E+00
-5.00E+00
Current mA/cm^2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Voltage V
MEA 002 std
MEA 003 w/ dopamine

PERFORMANCE CURVE RESULTS

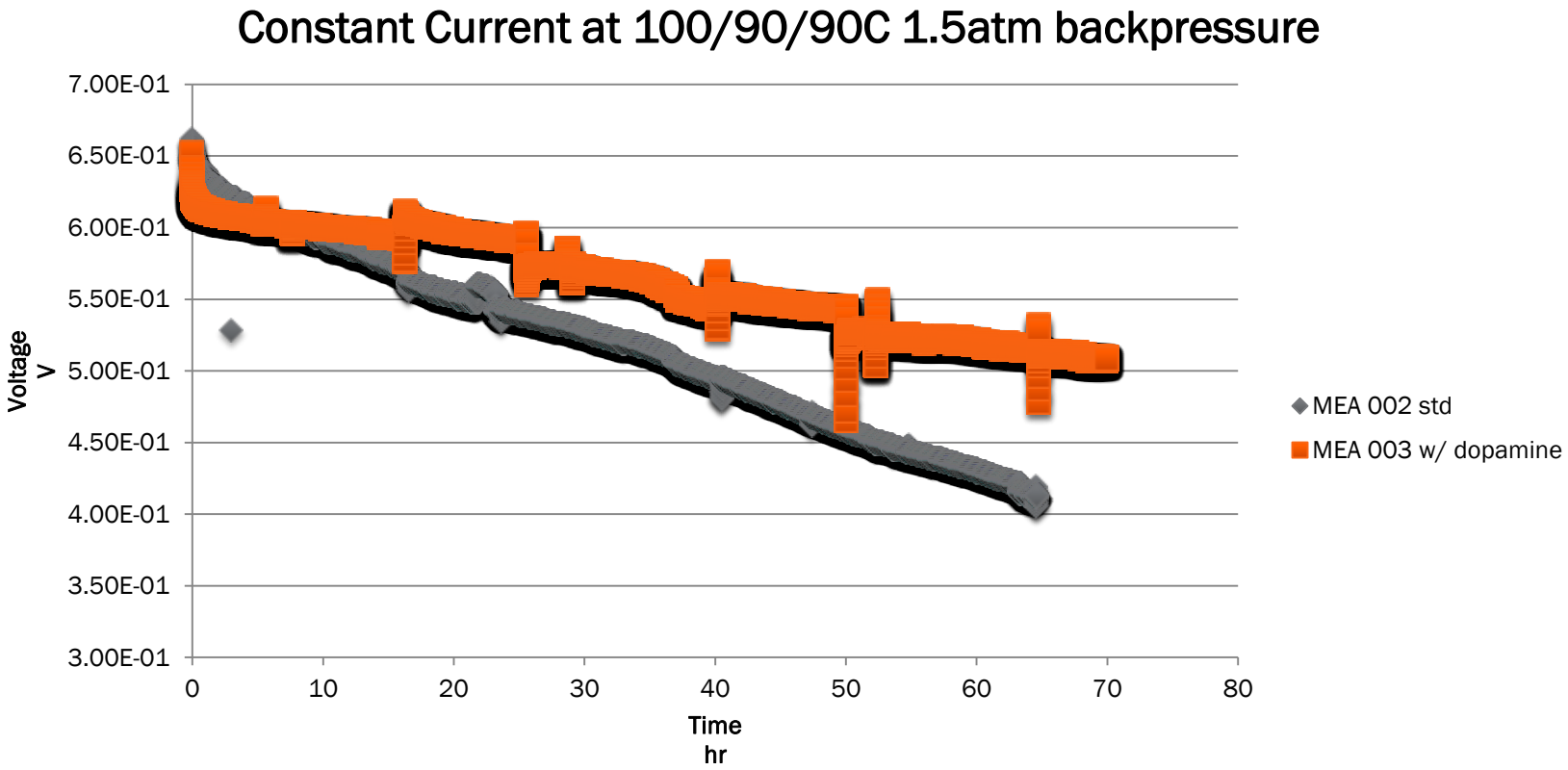


OCV

MEA002: 1.0013V

MEA003: .98165V

LONG TERM TEST RESULTS



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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