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Aerogel Based Catalyst PEMFCs Operating at Room Temperature

A. SMIRNOVA^a,
X. DONG^b, H. HARA^b, N. SAMMES^c

^aUCONN , Materials Science and Eng.
Dept./CGFCC

^bAerogel Composite, LLC

^cUCONN , Mechanical Engineering
Department/CGFCC





- CGFCC-World-Class Facility linked with the UCONN
- Founded in 2002

Construction of the building was subsidized through a \$2 million grant from the U.S. Department of Commerce and Economic Development

About 50 associated faculty members perform cutting-edge research to develop state-of-the-art fuel cell and hydrogen fueling systems, based on solid oxides and polymer electrolytes (SOFC, PCFC, DMFC, and PEMFC).

More than 50 students perform the work at the CGFCC related to the FC R&D.

AGENDA

1. Introduction

2. Experimental

3. Results and discussion

4. Conclusions

5. Acknowledgements

LOW-COST PEMFC

ITEMS OF COST-REDUCTION AND TECHNICAL TARGETS

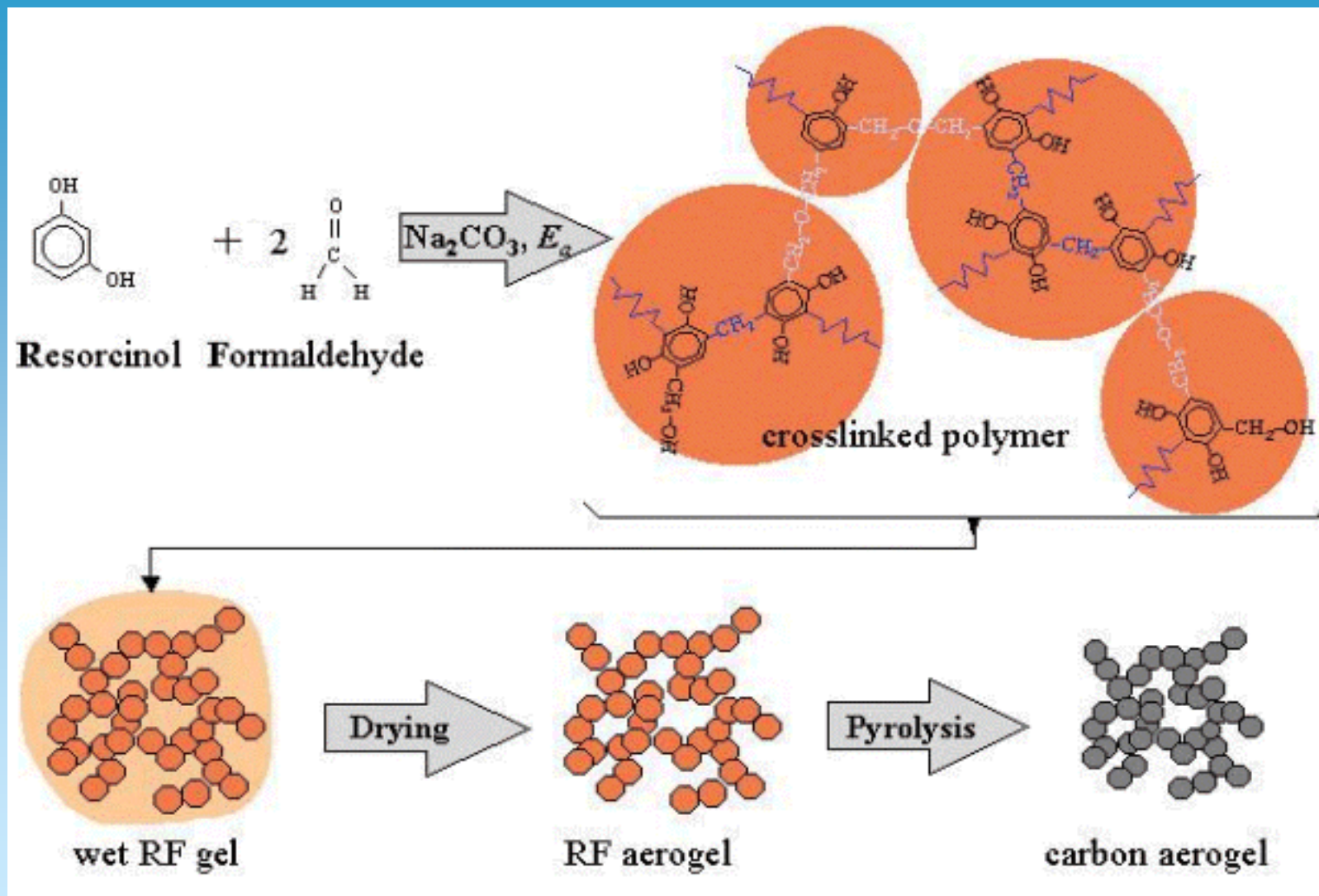
- Catalyst layer
- Membrane
- Construction materials
- System efficiency
- Concept of operation
- Cell Design
- Power density 0.8-0.9 W/cm² at 0.65 V
- Efficiency >55 %
- Pt-specific power density: 0.2 g_{Pt}/kW at 0.65V
- Pt loadings ≤ 0.15 mg/cm²

At least 5-fold reduction of Pt in the catalyst layer is needed

CARBON AEROGEL SUPPORTED Pt CATALYSTS (CASPC) VS. COMMERCIAL CATALYSTS

- SURFACE AREA OF CARBON
- SURFACE AREA OF NOBLE METAL
- NOBLE METAL UTILIZATION
- ELECTROCHEMICAL SURFACE AREA
- LONG-TERM STABILITY
- CARBON and Pt DEGRADATION RATES

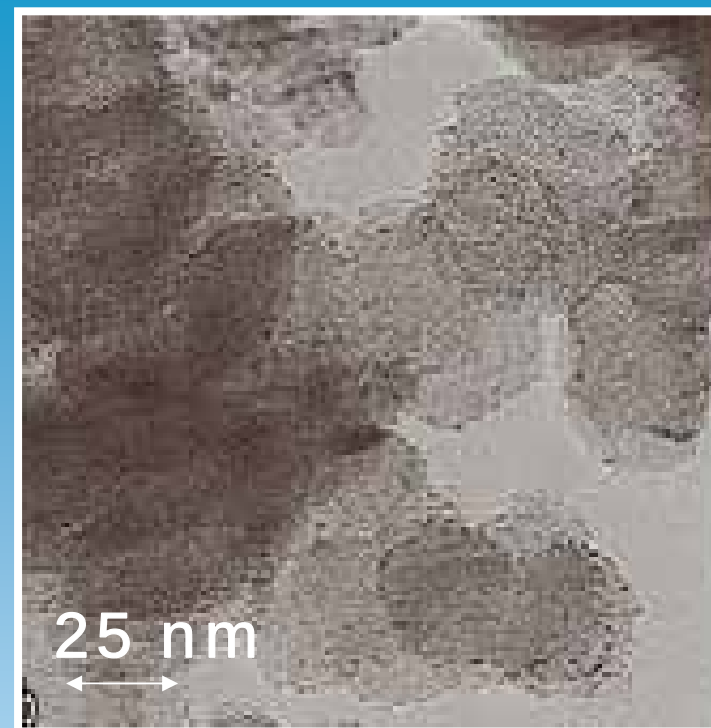
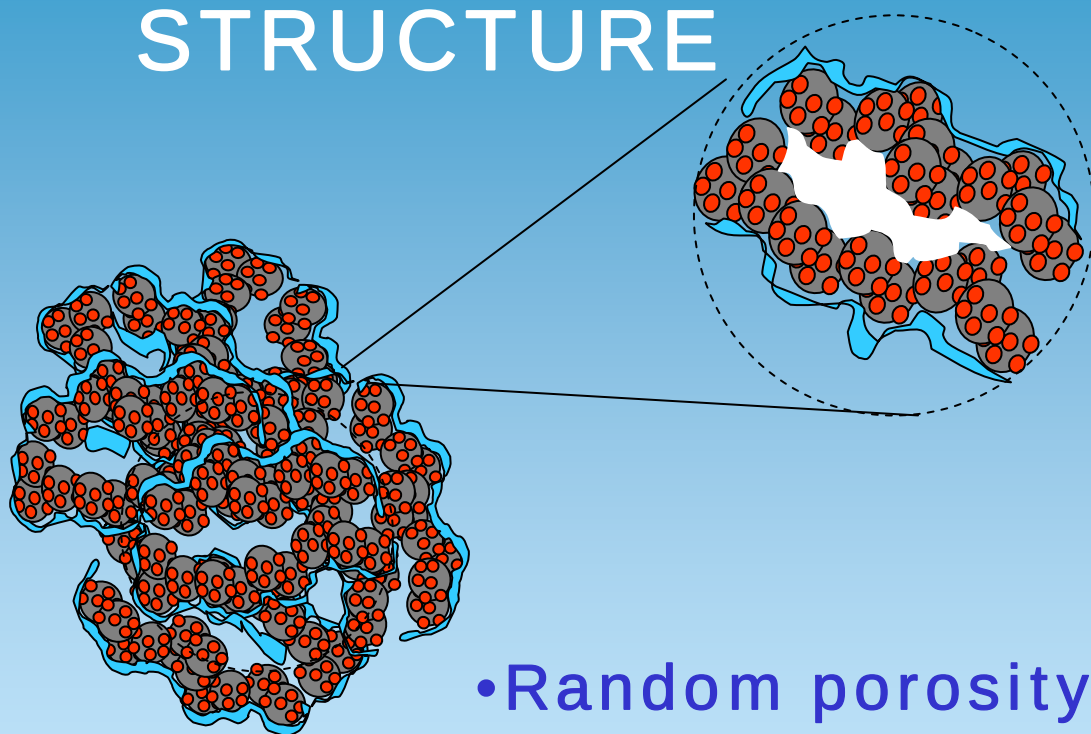
SYNTHESIS of CARBON AEROGELS



Polymerization;
gelation

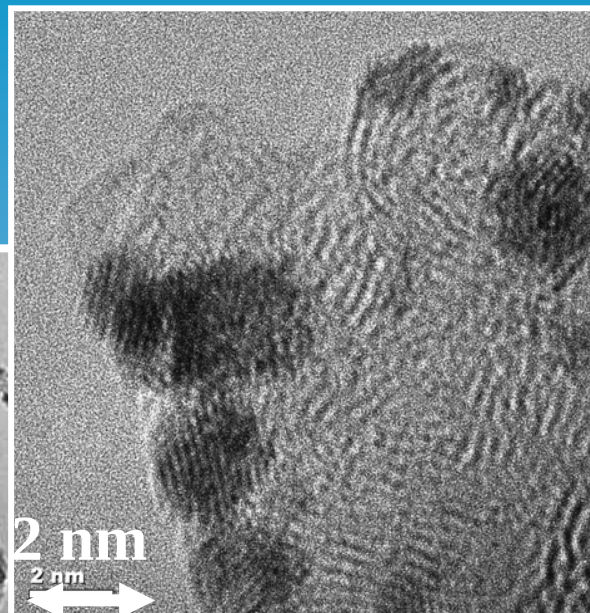
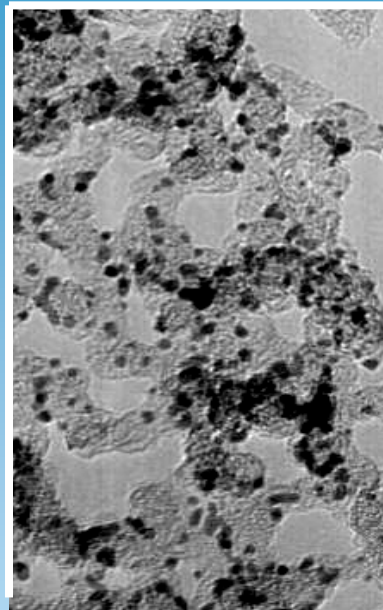
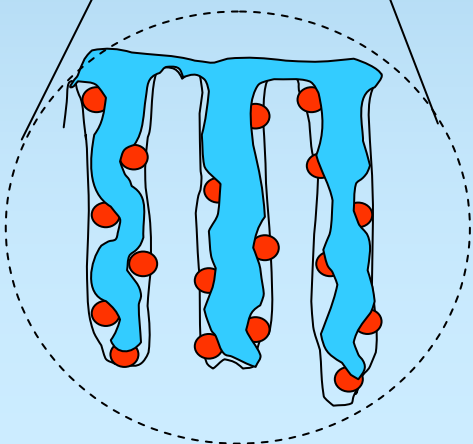
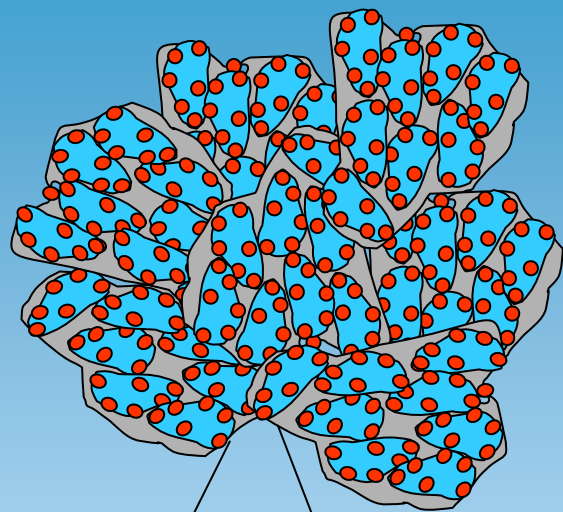
Supercritical
 CO_2 extraction

COMMERCIAL CATALYST STRUCTURE



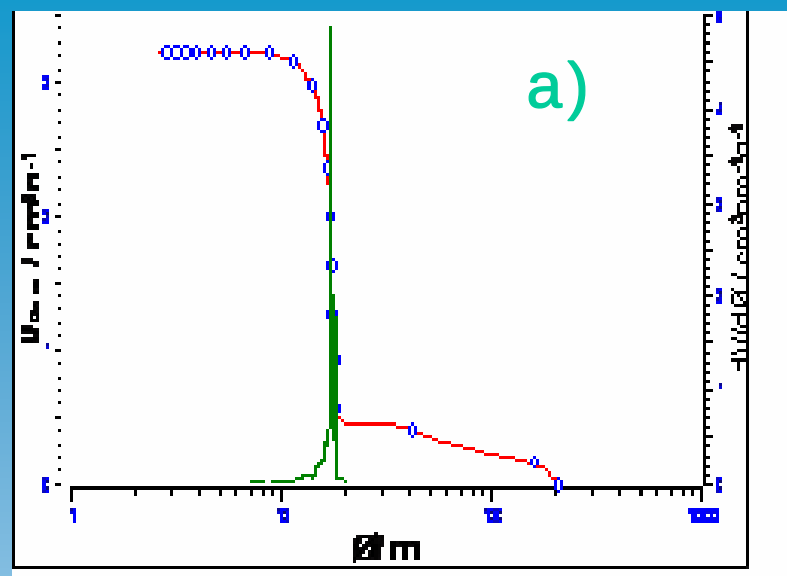
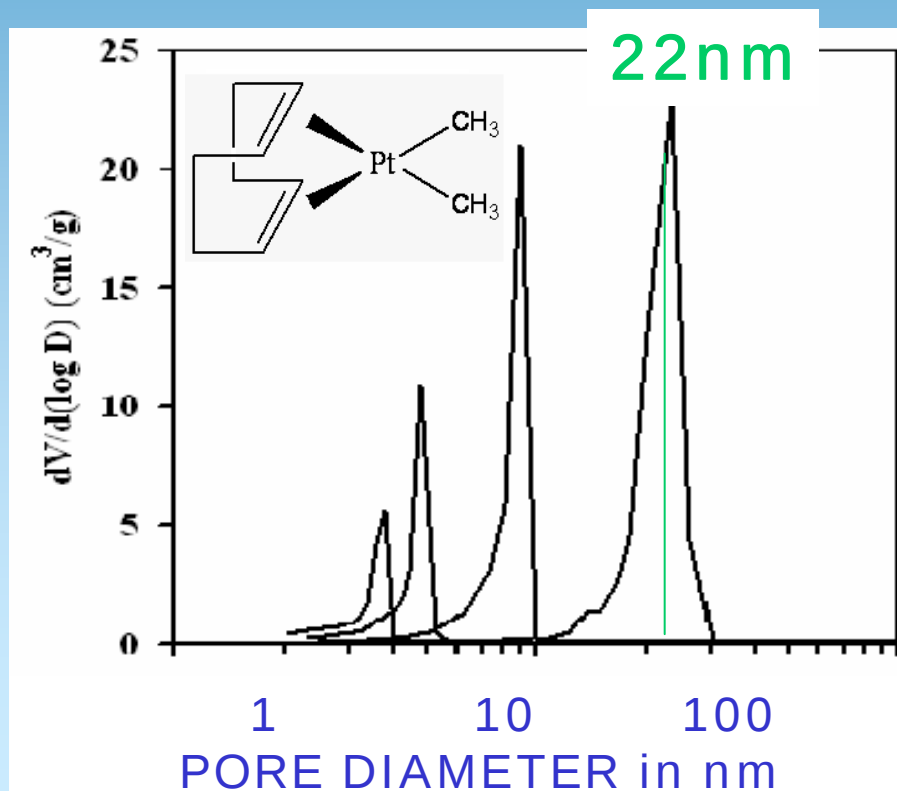
- Random porosity and nanostructure
- Non-even distribution of Nafion
- Low Pt utilization
- Tendency for agglomeration
- Presence of ionic impurities

STRUCTURE OF AEROGEL SUPPORTED Pt CATALYST

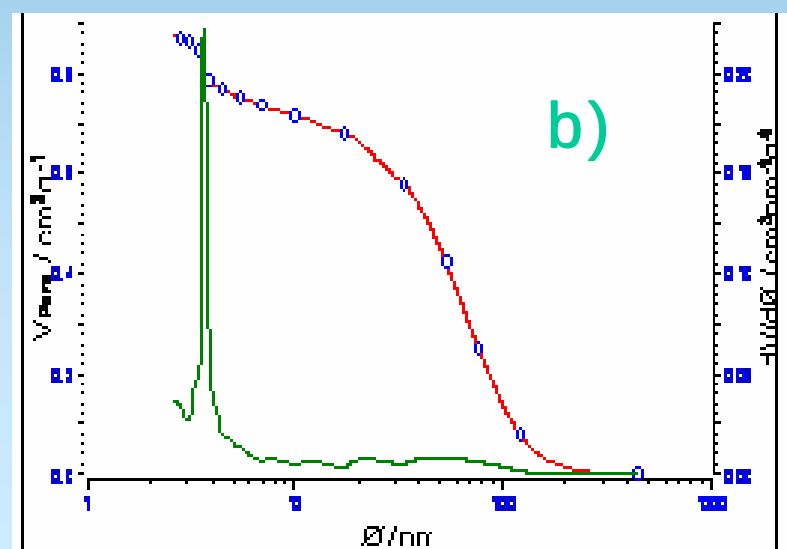


- Reproducible porosity
- Even distribution of Nafion inside the pores
- Absence of ionic impurities
- Less tendency for agglomeration
- High Pt dispersion
- High Pt and carbon surface area

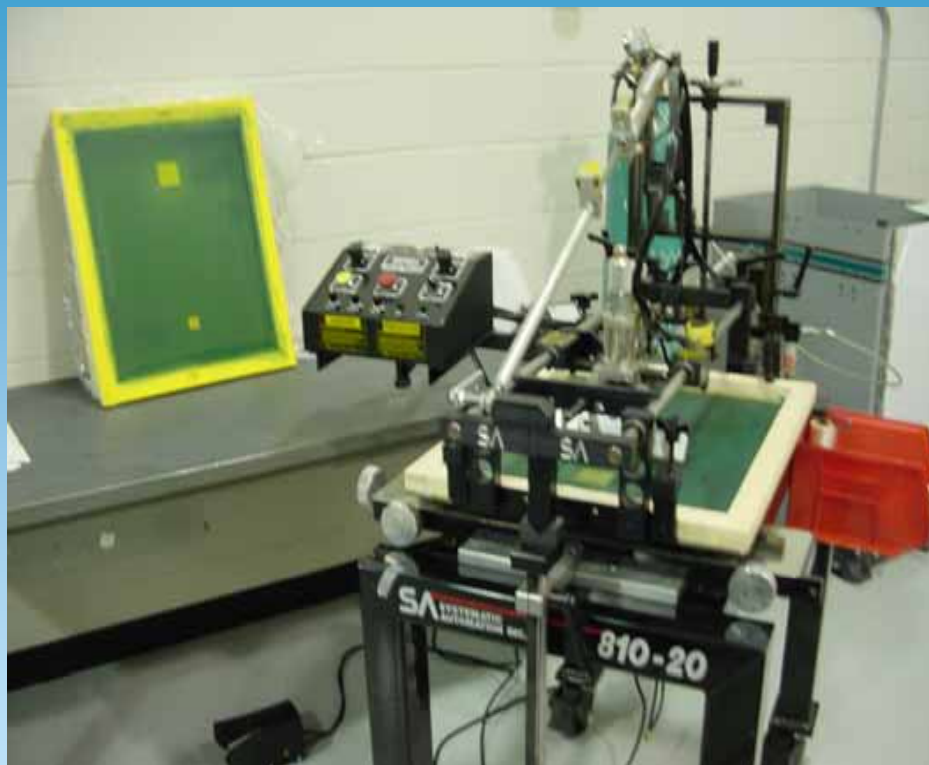
Control of pore size distribution in CASPC by changing reactant concentration



BET data for (a) CASPC
(b) commercial catalyst



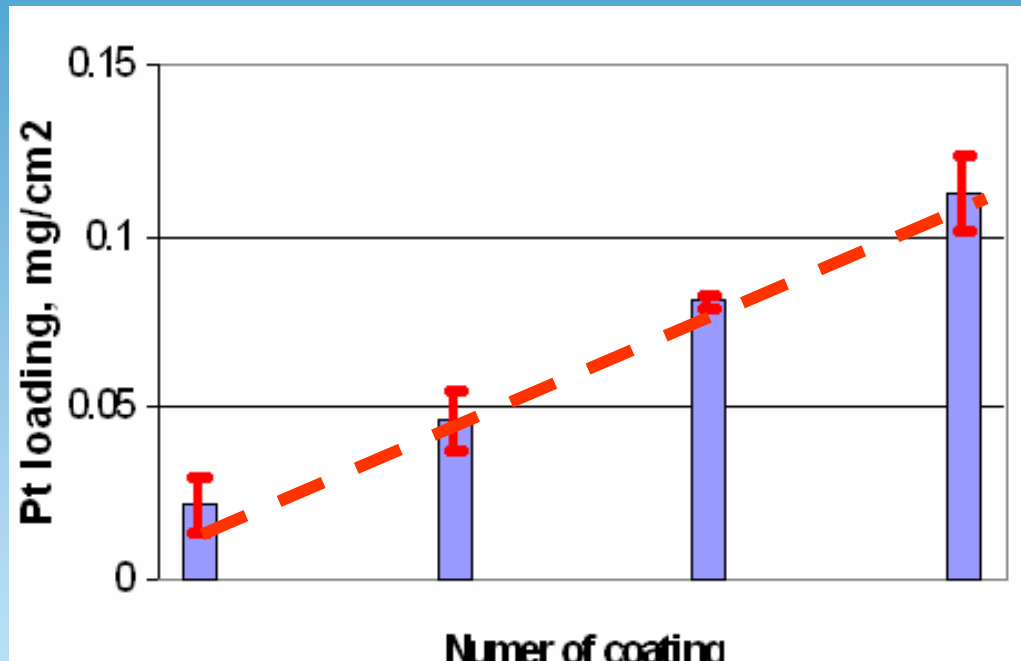
PREPARATION OF CASPC CATALYST LAYERS



SCREEN-PRINTING TECHNIQUE

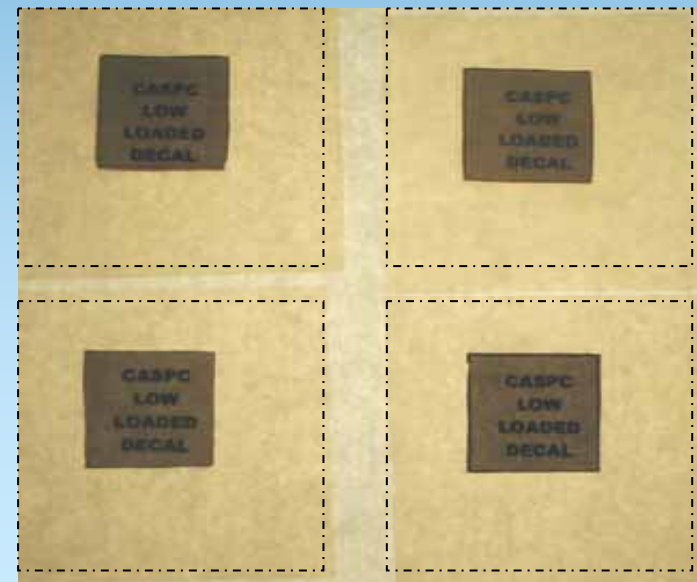
Systematic Automation Model 810 Series Screen Printer used for manufacturing of cathode and anode catalyst layers.

Manufacturing of Teflon substrates with ultra thin CASPC layers

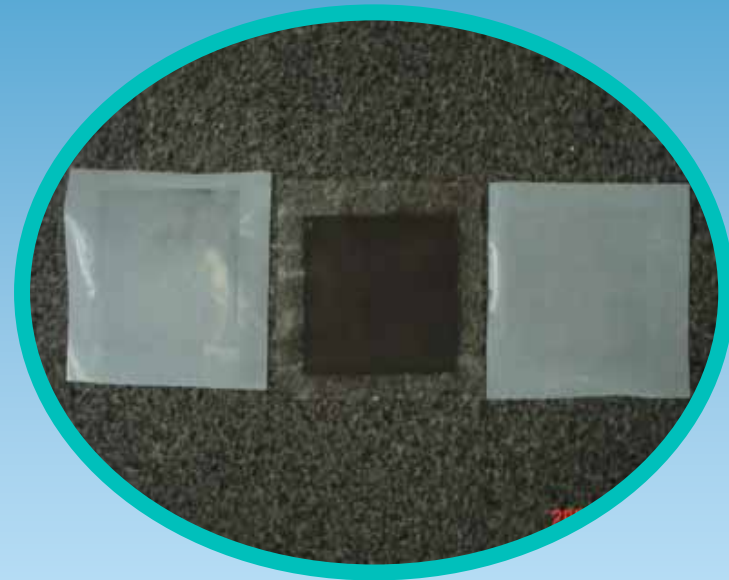
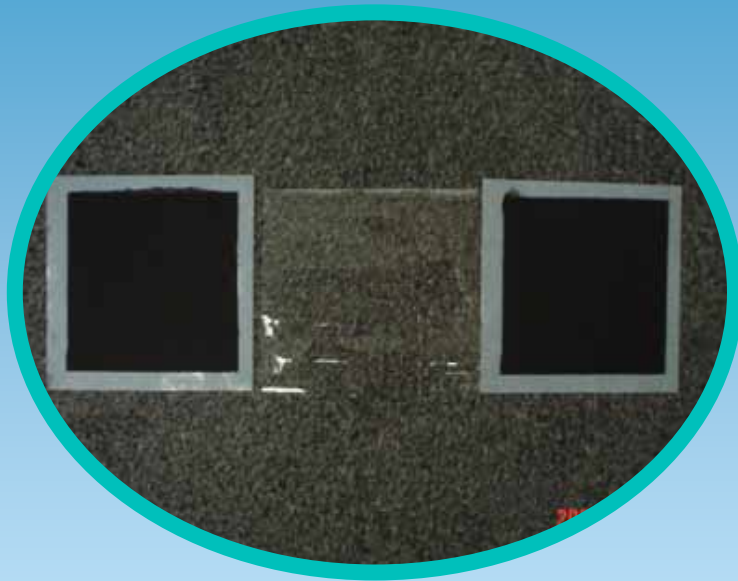


Four depositions are needed to achieve the targeted value of 0.1 mg/cm^2 using the polyester screen with 280 mesh from SAATI print

Low loading of the catalyst ($\leq 1 \text{ mg/cm}^2$) allow for reading through the layer

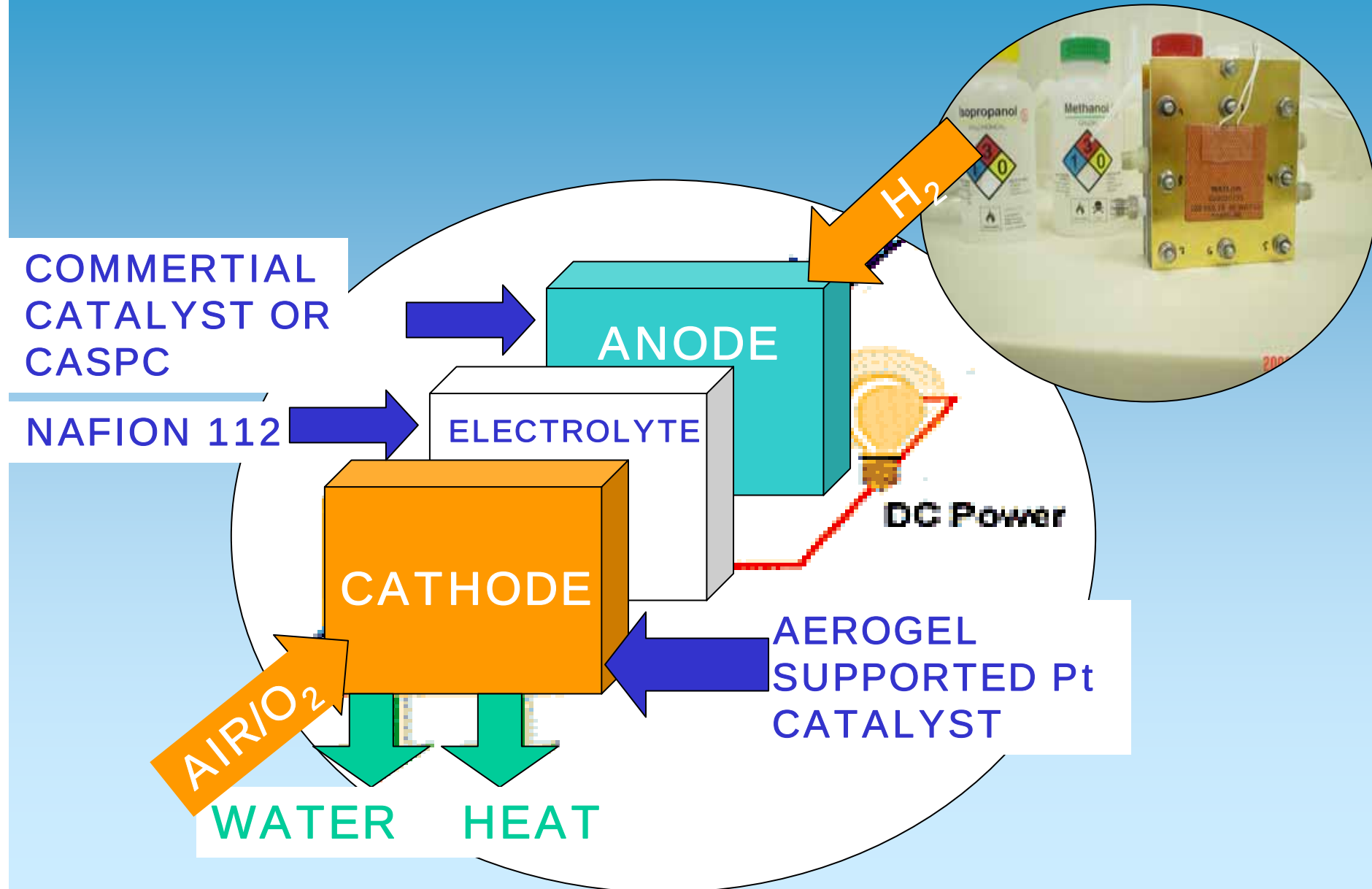


FABRICATION OF MEAs USING HOT-PRESSING TECHNIQUE

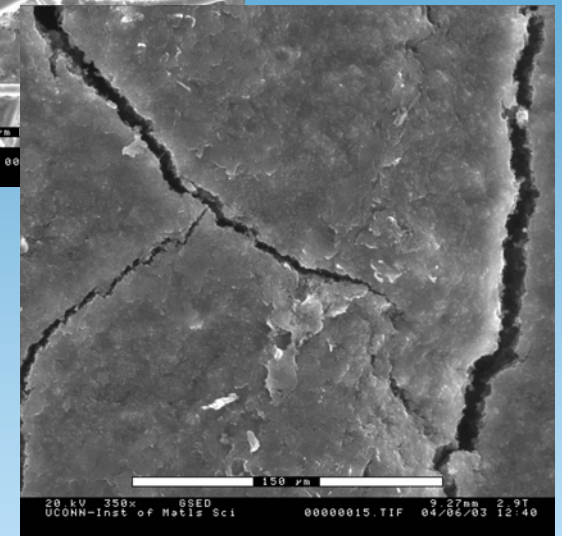
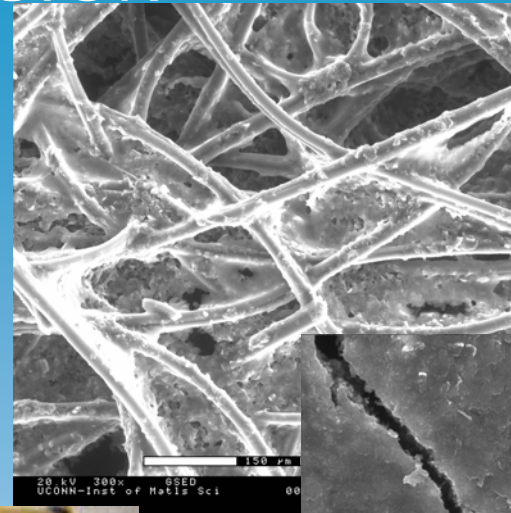
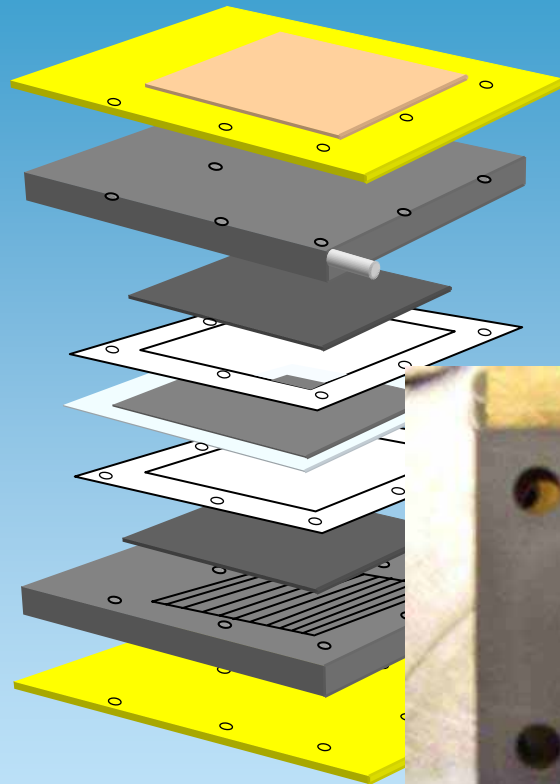


MEA components before and after hot-pressing at 130°C. No catalyst is left of the surface of the Teflon substrate after hot-pressing procedure.

CELL DESIGN and HARDWARE



SINGLE CELL ASSEMBLY DESIGN AND MATERIALS



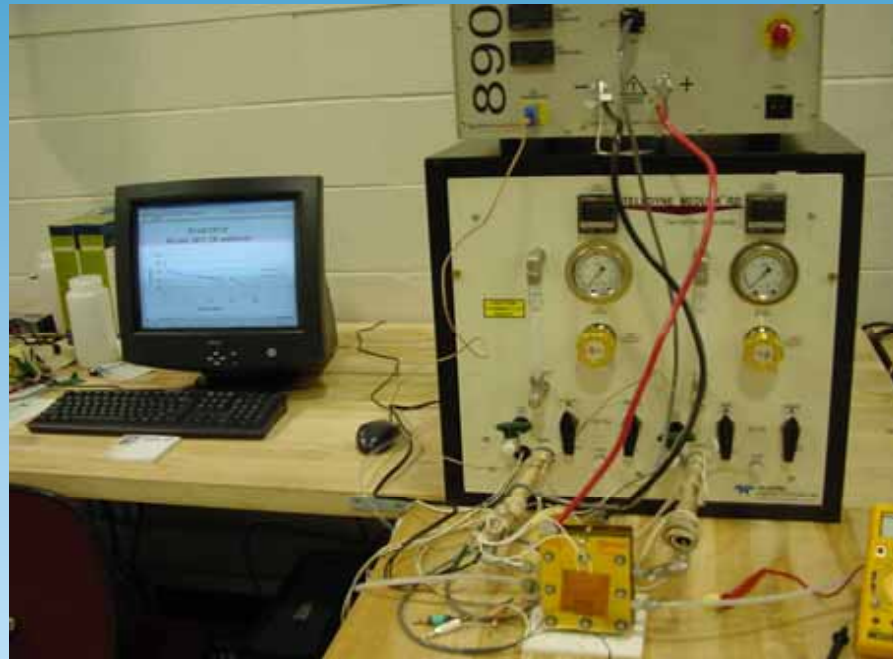
6.25 cm²

SINGLE SERPENTINE

CARBON BIPOLAR PLATE

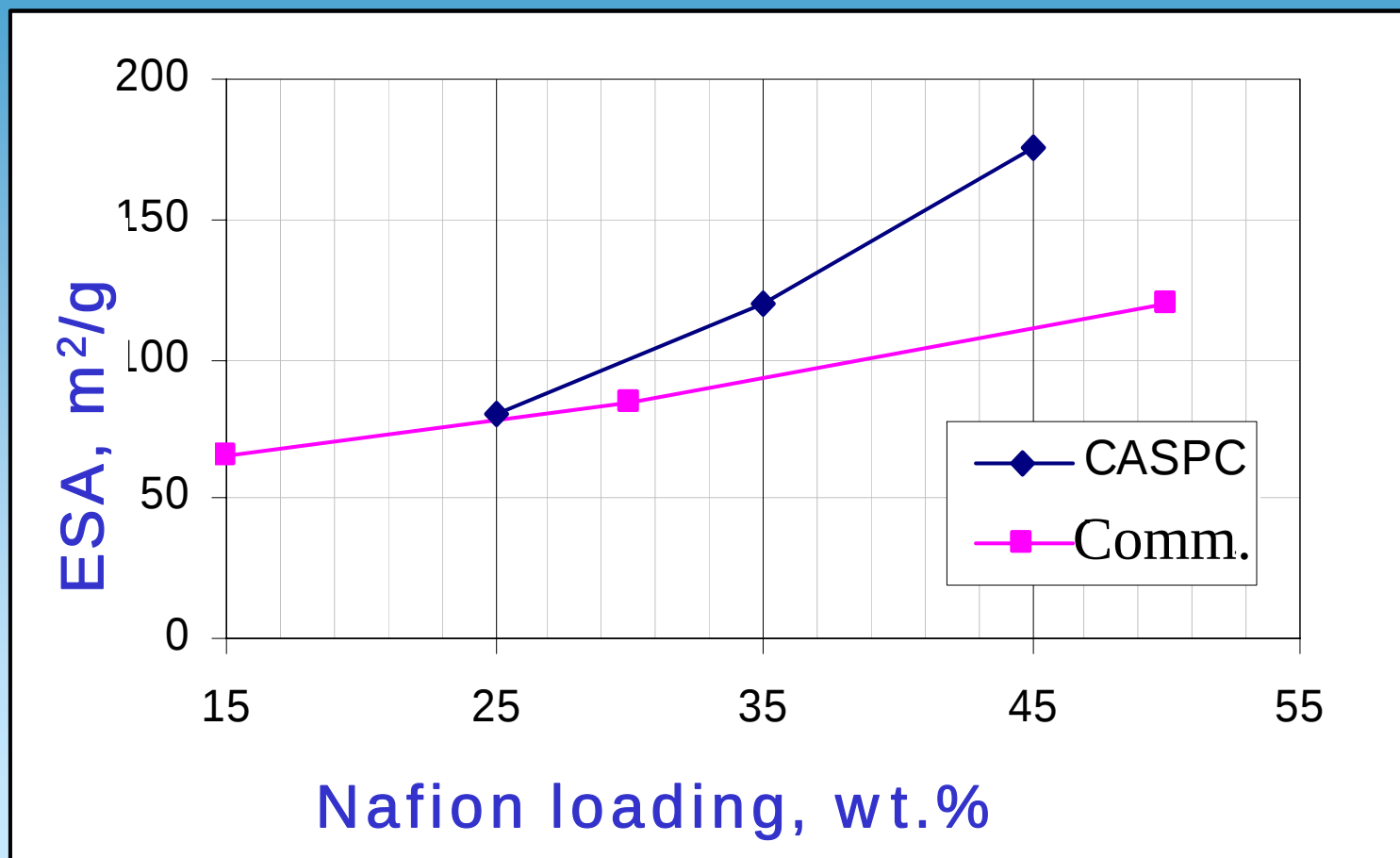
SGL 10BB
GAS-
DIFFUSION
LAYER
STRUCTURE
(two sides)

PERFORMANCE OF AEROGEL-SUPPORTED Pt CATALYSTS IN FUEL-CELL OPERATION

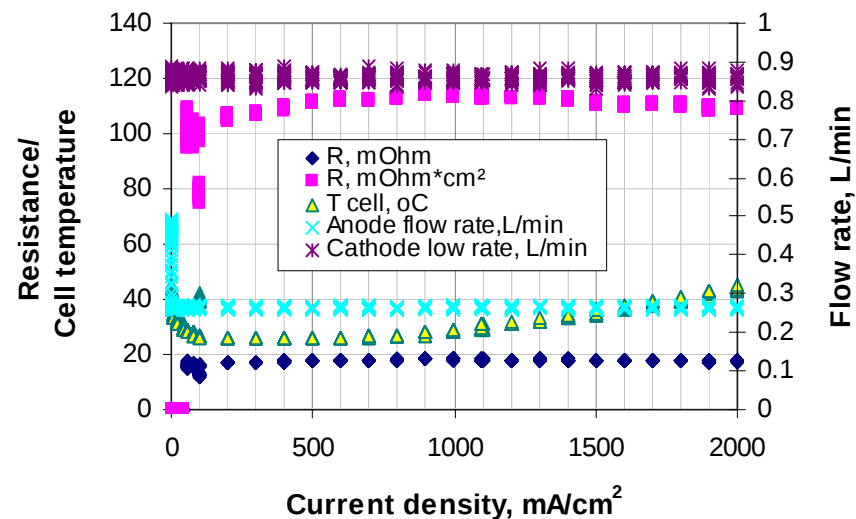
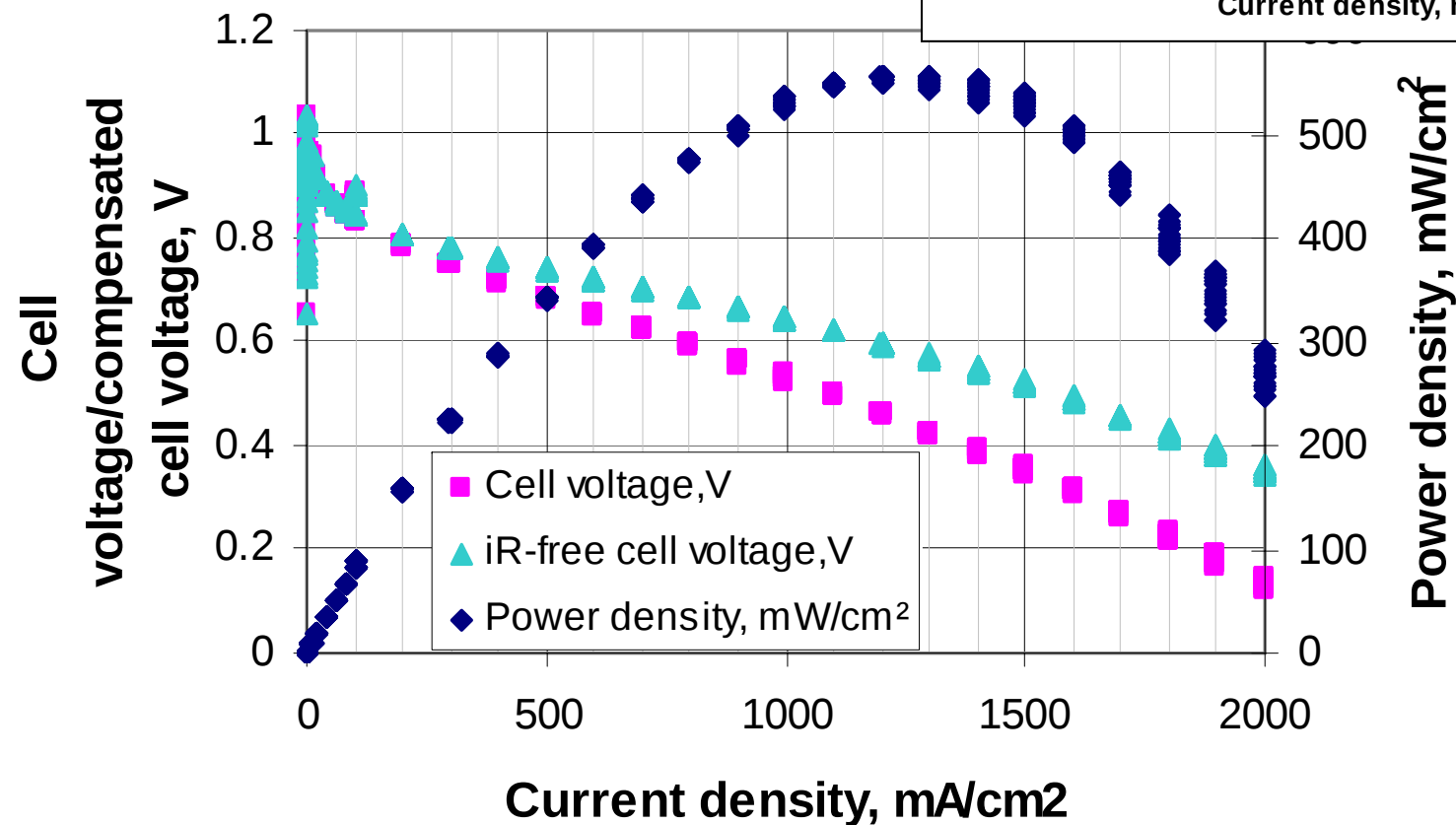


Teledyne Medusa Fuel Cell test station with
Scribner Associates, Inc. Series 890B load
system at the CGFCC

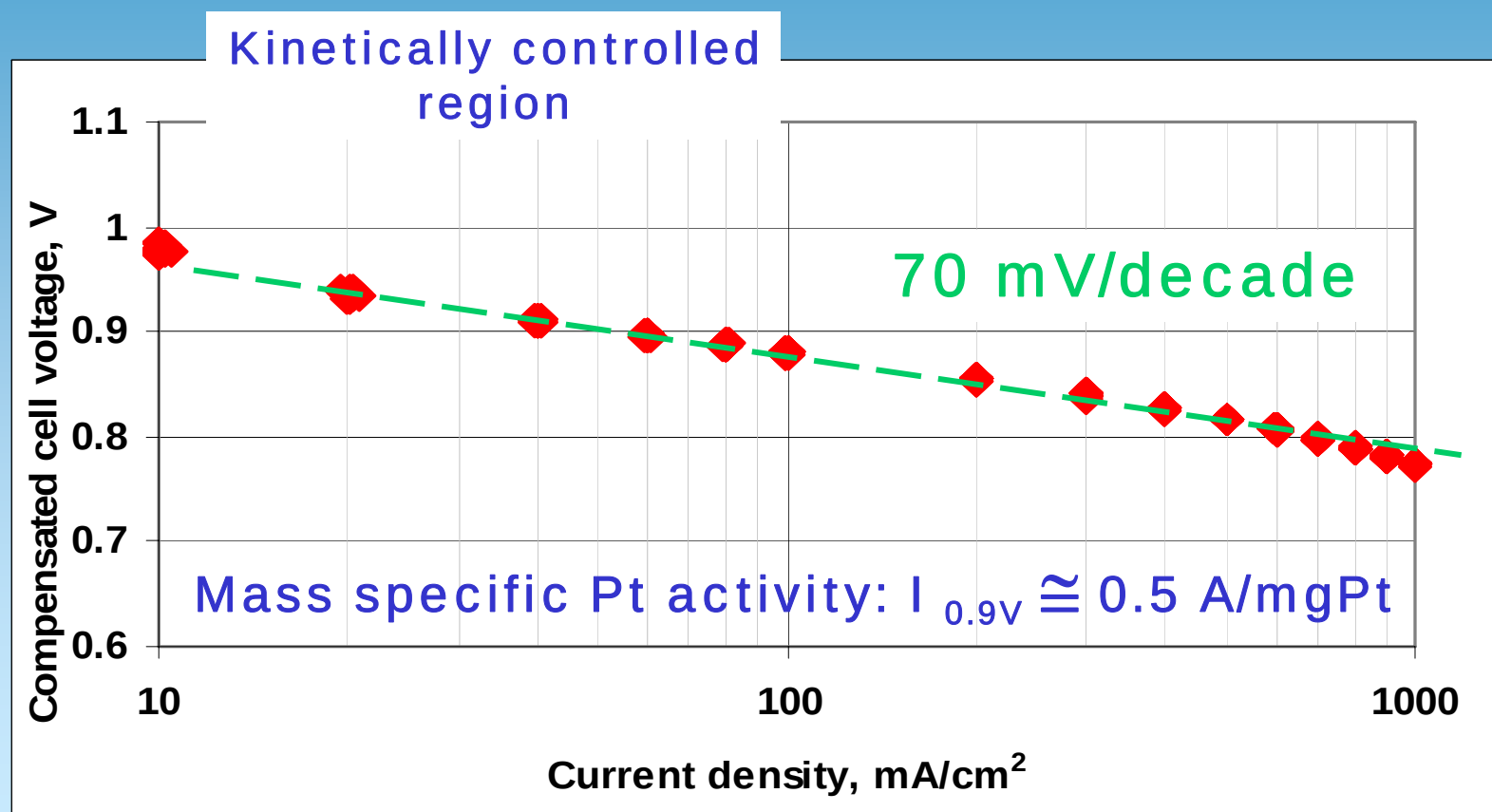
Electrochemical surface area (ESA) vs. Nafion loading for commercial (45%Pt) and aerogel supported catalyst (20% of Pt)



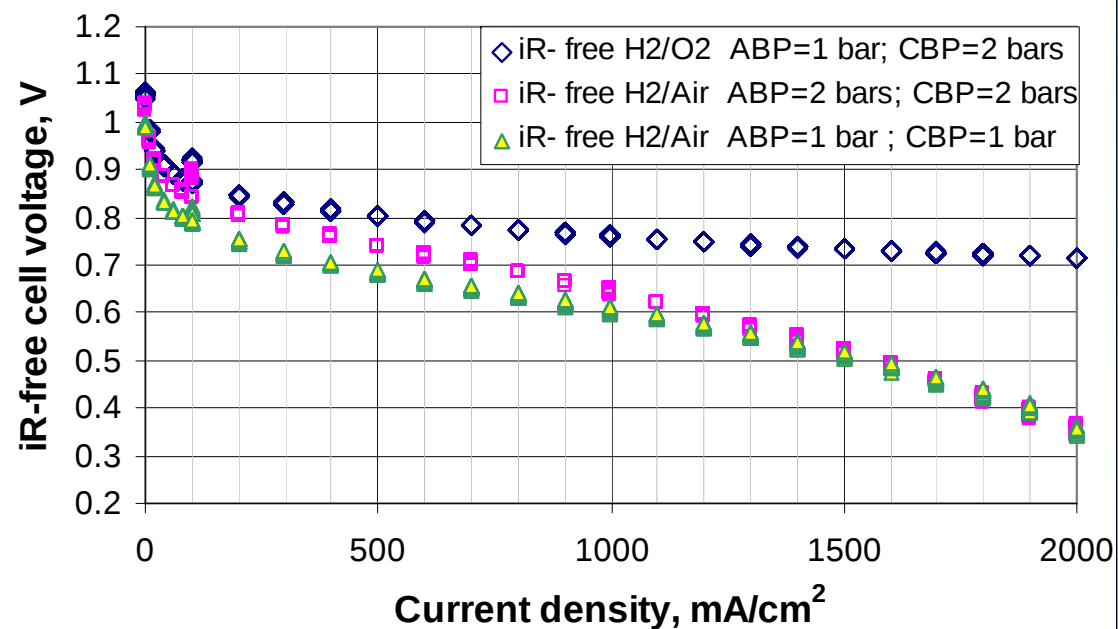
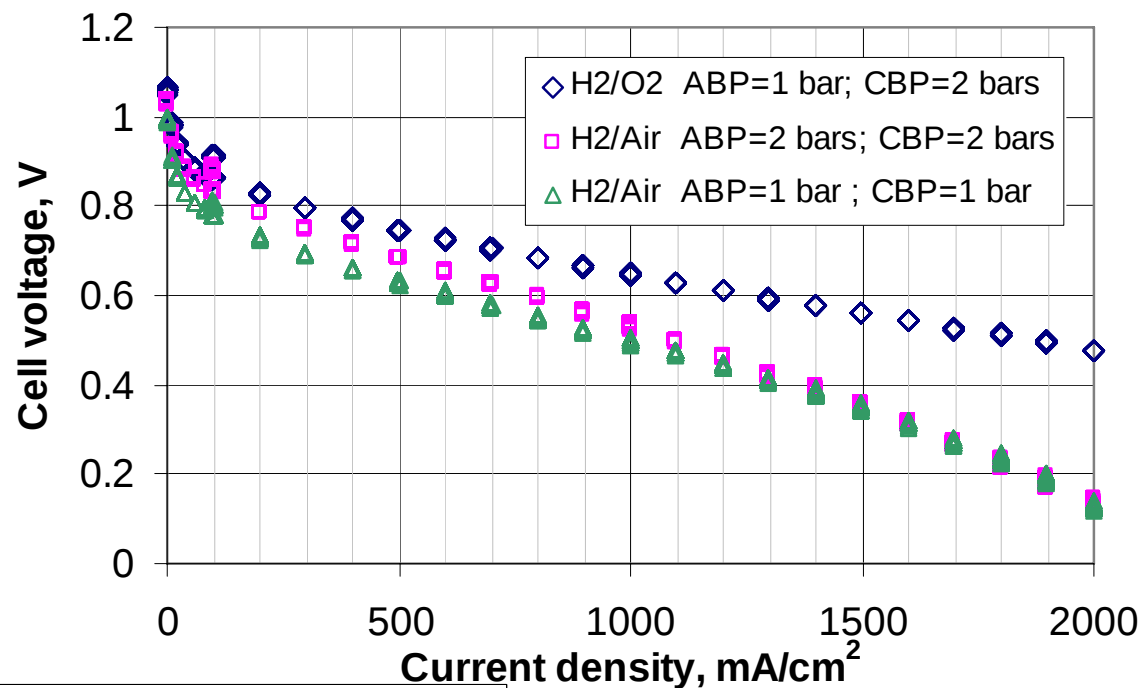
PEMFC performance at 22°C in H₂/air ; after 300 hours of testing ABP= 1atm CBP=2



Tafel plots for the aerogel supported Pt catalyst at 50°C in hydrogen/oxygen at 1atm backpressure

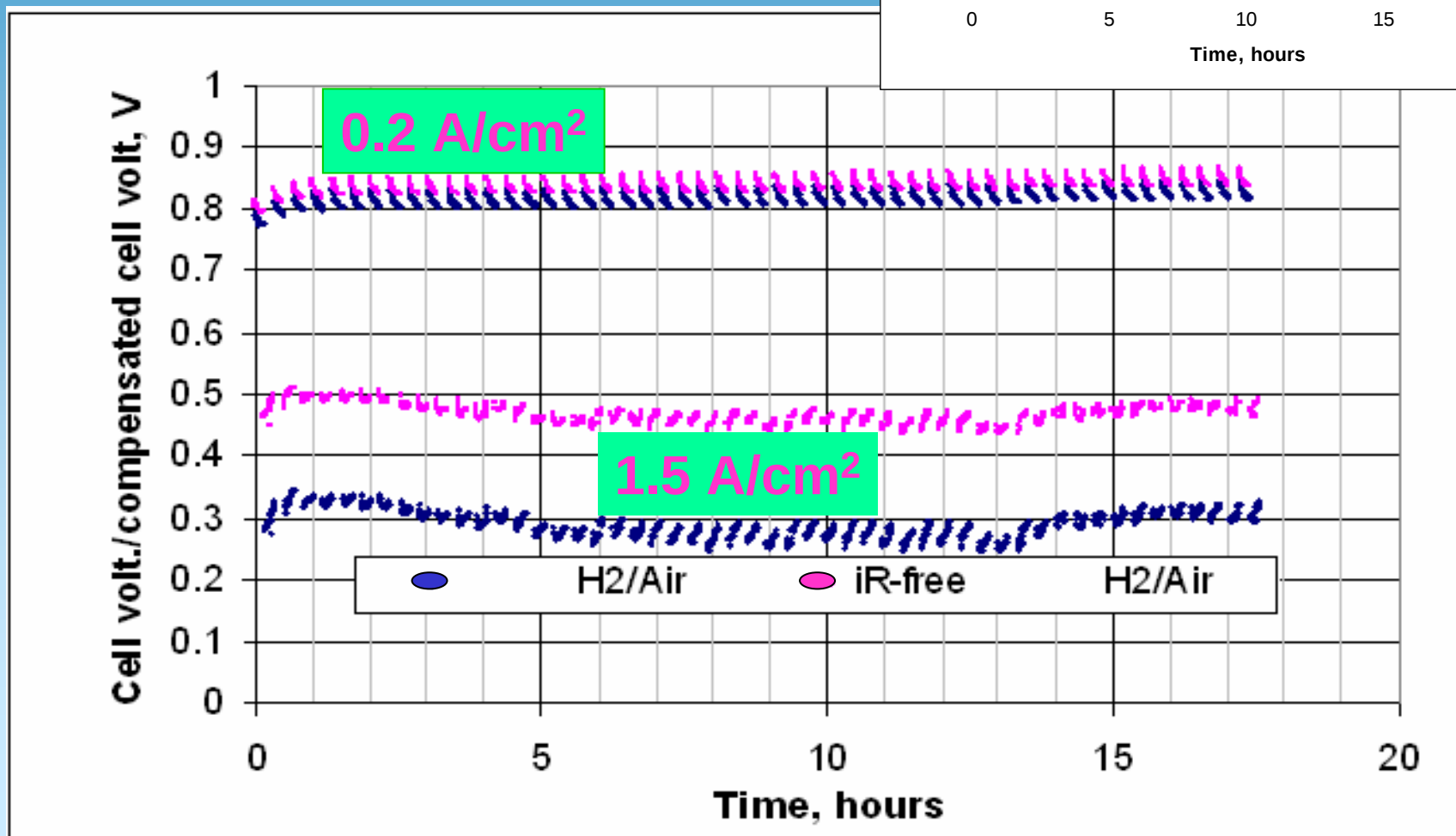
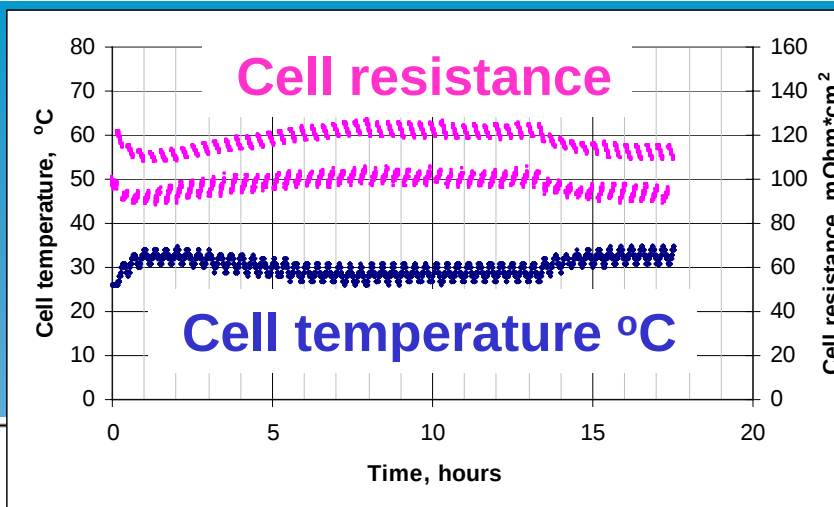


Influence of backpressure

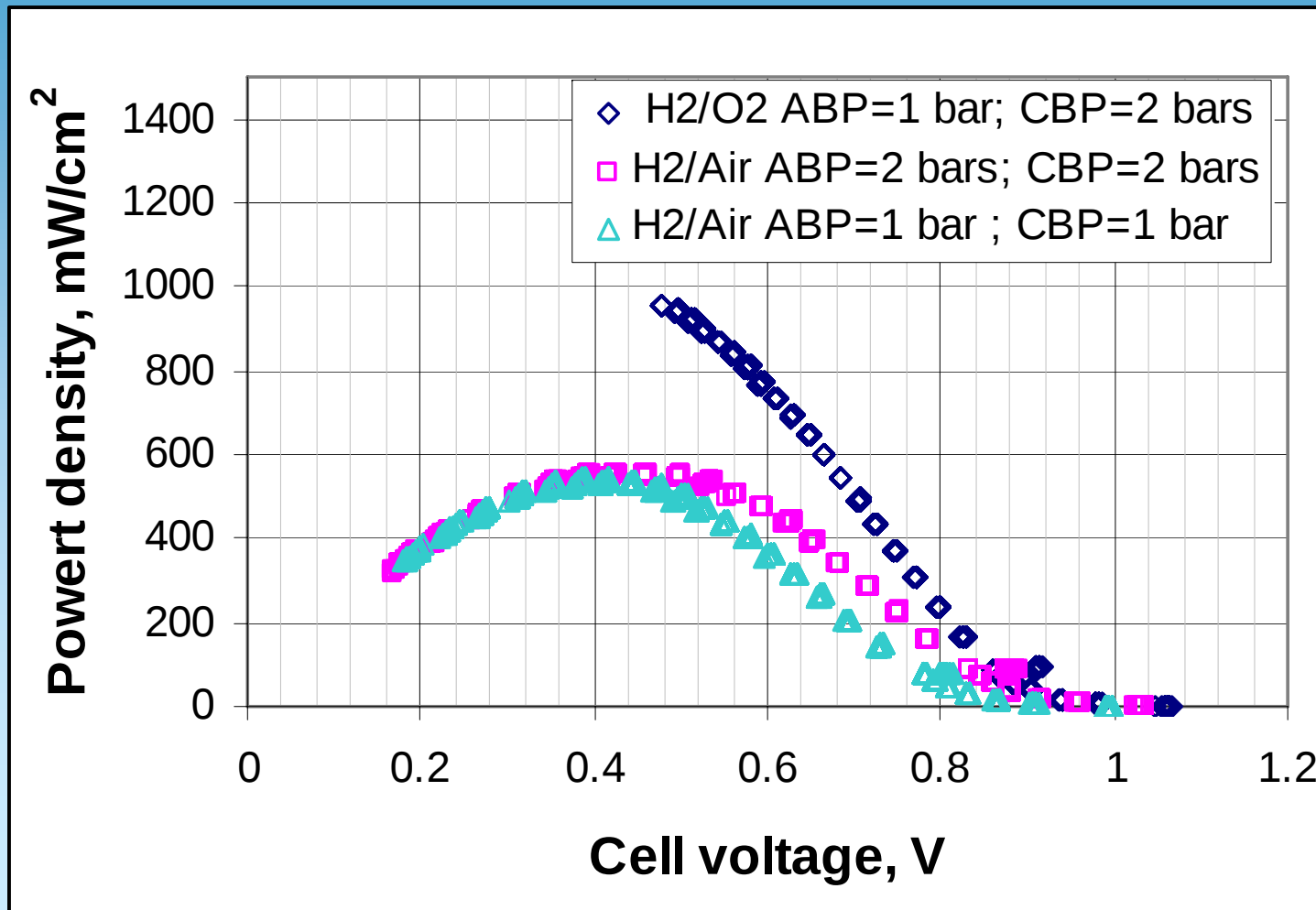


iR-free
performance

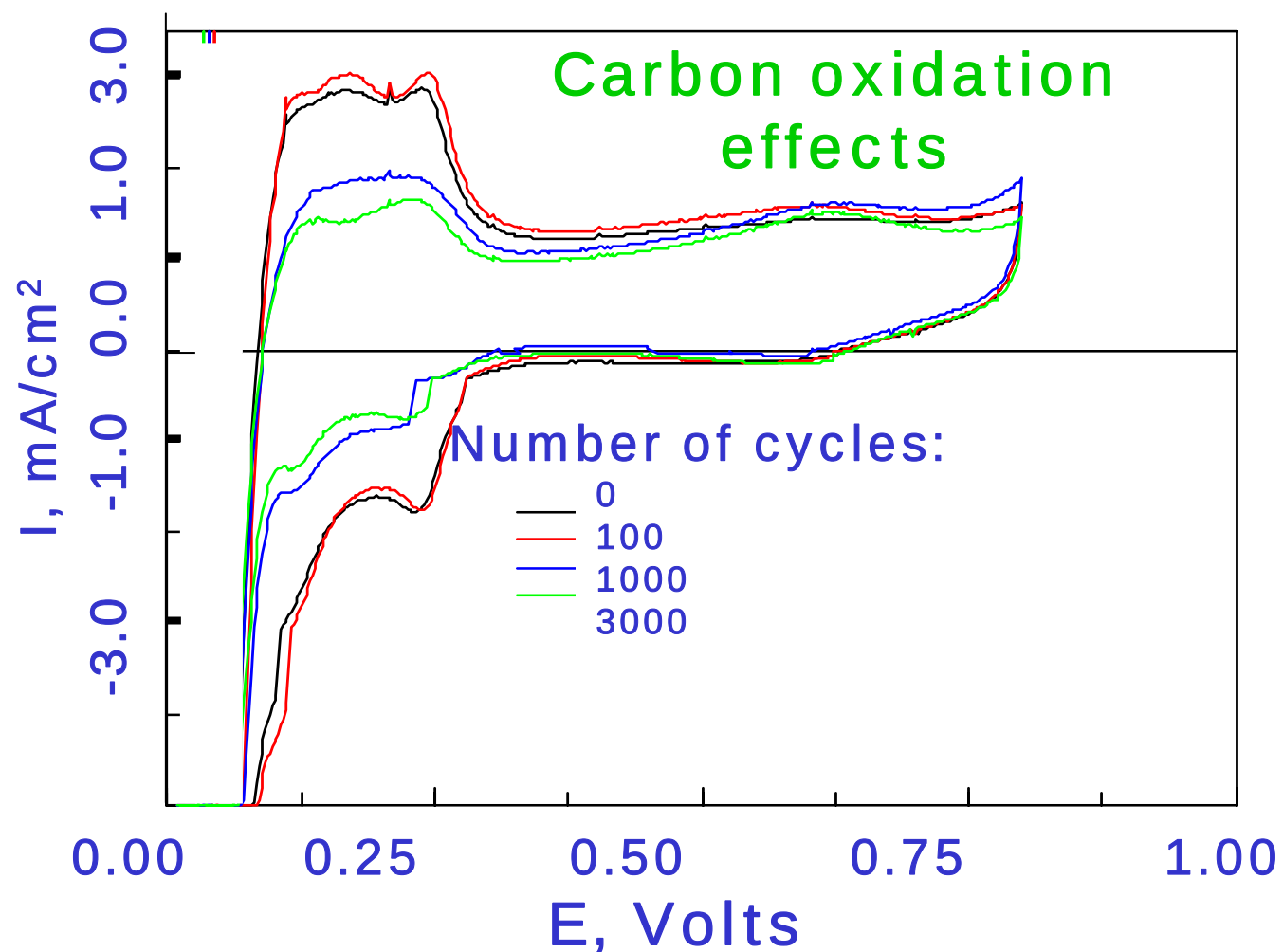
PEMFC performance after
200 hours of operation at
 0.2 A/cm^2 and 1.5 A/cm^2
in H_2/air at 28°C , constant flow rate,
and 2 bars absolute pressure



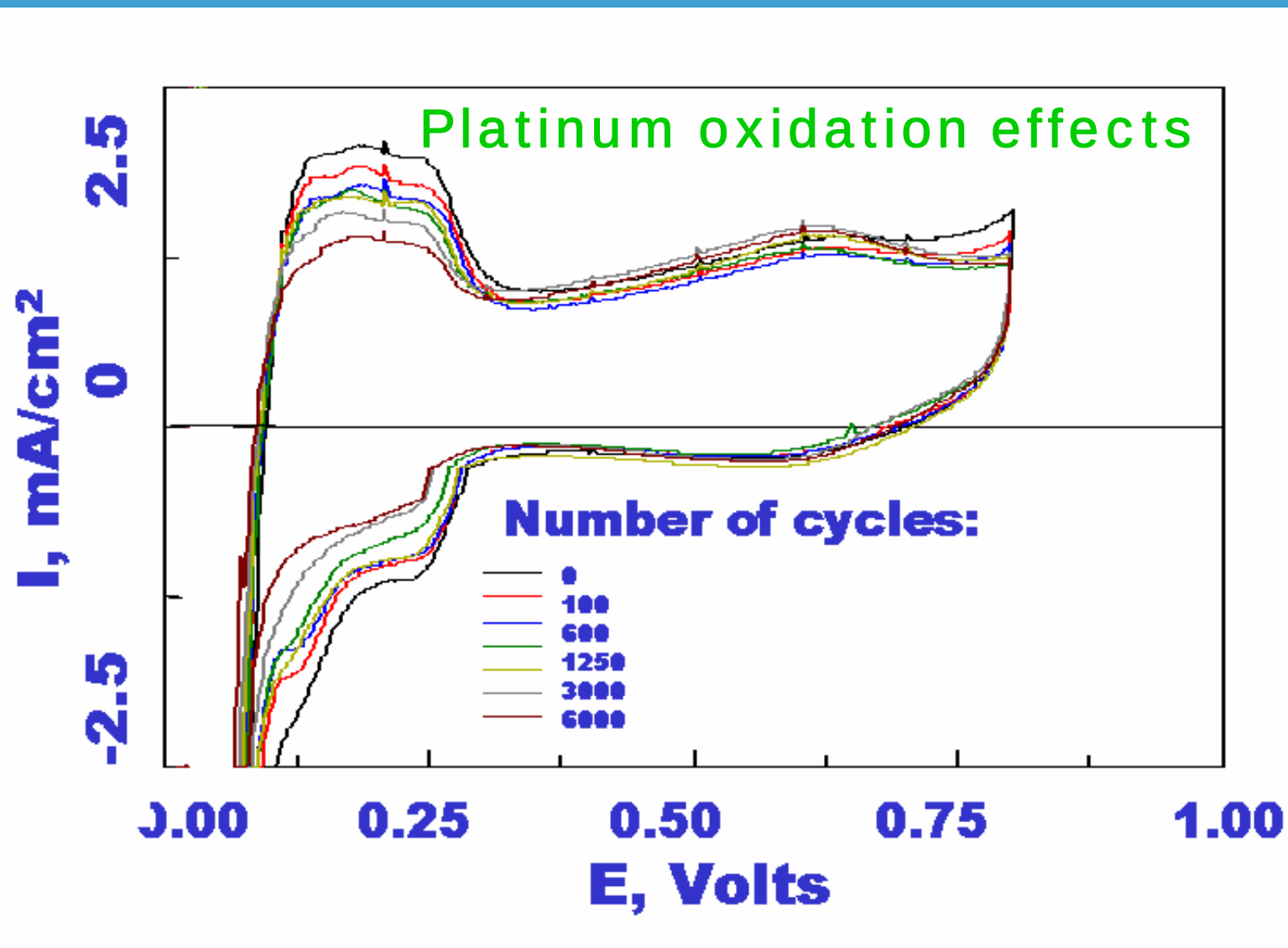
Power density vs. cell voltage for the cell with
0.1 mg/cm² CASPC in cathode catalyst layer at
25°C in H₂/Air and H₂/O₂



CV plots for CASPC catalyst after cycling from 0.6 to 1.2 V at 30°C



CV plots for CASPC catalyst after cycling from 0.6 to 1.0 V at 30°C



CONCLUSIONS

- Aerogel supported Pt catalyst have been successfully tested in PEMFCs with 0.1 mg/cm^2 loading at room temperature
- Demonstrated high OCV, close to theoretical Tafel slope and high electrochemical surface area
- Power density at 0.6 V is about 0.55 mW/cm^2

Further improvement in the cell performance can be achieved by optimization of the aerogel catalysts structure and cathode catalyst layer composition.

Acknowledgements

Financial support from Aerogel
Composite, LLC is gratefully
acknowledged

THANK YOU FOR YOUR ATTENTION