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Understanding the Degradation Mechanisms of Membrane-Electrode-Assembly for High Temperature PEMFCs and Optimization of the Individual Components

DEMMEA

Joint Technology Initiatives-CP

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Partners

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PRAGUE

Outline

- Project description
- Preliminary results
- Future activities

Main Objectives

- Understand the functional operation as well as the degradation phenomena of high temperature H_3PO_4 imbibed PEM and its electrochemical interface.

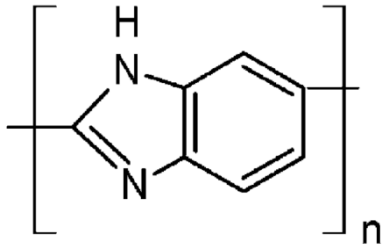
- Modeling in correlation with experimental observations.

- Combined use of advanced experimental techniques. Design and development of accelerated tests and prediction tools for the MEA's performance.

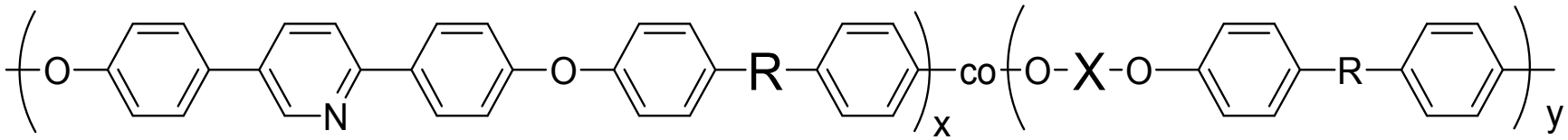
- Make targeted modifications on the MEA system.

Concerns of the DEMMEA project

1. High Temperature Polymer Electrolyte Membranes



AB-PBI and variants



Advent PEMs

- ✓ Study of oxidative stability: Fenton test combined with NMR, SEC, Raman, XPS, DMA.
- ✓ Retention of acid and/or water: TGA, SEM, TEM
- ✓ Study of the proton conductivity by means of 4-probe current interruption method. Effect of polymer matrix and water vapor.

Concerns of the DEMMEA project

2. Catalyst and Catalytic Layers

Catalyst degradation:

(i) platinum dissolution and redeposition known as Ostwald ripening

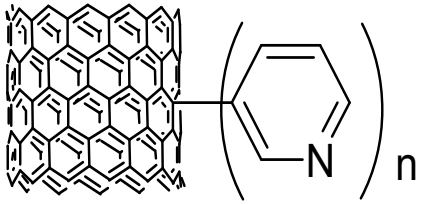
(ii) coalescence of platinum nanoparticles via platinum nanocrystallite migration on the carbon support

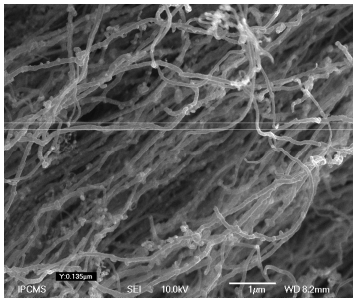
(iii) platinum particle agglomeration triggered by corrosion of carbon support and leaching of Pt and alloyed metals

Concerns of the DEMMEA project

2. Catalyst and Catalytic Layers

- ✓ Study of catalyst stability and utilization by means of XRD, TEM, SEM-EDX, TGA, H2 chemisorption, Raman, XPS, RRDE and CV experiments & X-Ray tomography.
- ✓ Mathematical modeling of catalyst degradation.
- ✓ Proposal of a stable electrocatalytic layer with improved metal electrocatalyst utilization.

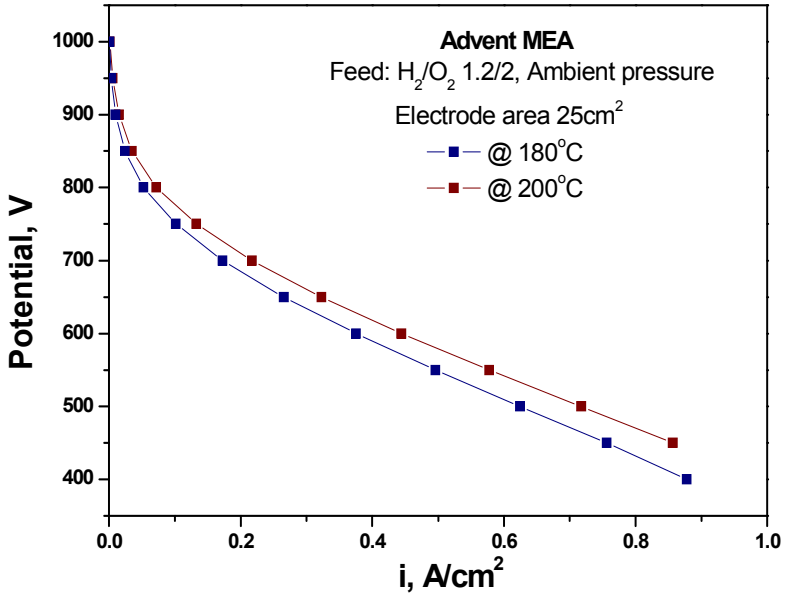




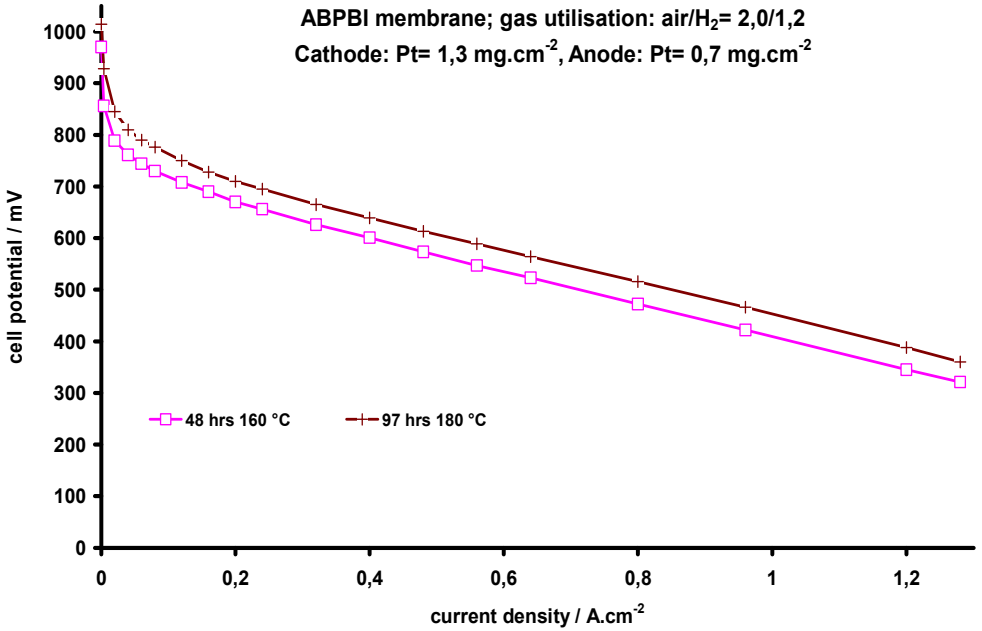
New catalysts based on Pt supported on finely dispersed or structurally organized modified carbon supports (nanotubes, pyrolytic carbon).

Concerns of the DEMMEA project

3. Membrane Electrode Assembly



Study be means of combined electrochemical & spectroscopic investigation techniques.



✓ Determination and optimization of Pt electrocatalytic utilization.

✓ Define a protocol correlating the accelerated MEA's degradation rates with normal operation.

Concerns of the DEMMEA project

3. Membrane Electrode Assembly

In-situ measurements

- Catalyst structure: In-situ X-ray absorption
- Adsorbed species on the catalyst: Delta μ XANES technique
- Electrochemical metal-electrolyte interface: Ambient Pressure Photoelectron Spectroscopy (APES)
- Long term testing of the FC: I-V plots, AC Impedance, CV
- Parameters that affect the performance: I-V plots, AC Impedance

Concerns of the DEMMEA project

3. Membrane Electrode Assembly

Post mortem analysis

- MEA: Pt corrosion: TEM-EDX
- PEM degradation: NMR, SEC, Raman, XPS,
- Electrode: EDX and EFTEM

  Quantitative determination of EASA of porous electrodes
- Catalyst: XRD, H_2 chemisorption, Raman, XPS

The goal

Tailormade optimization of the MEA into a commercially reliable product for stack manufacturers.