Fuel cells and hydrogen
Joint undertaking

Programme Review Day 2011
Brussels, 22 November

New Energy World JU
fuel cells & hydrogen for sustainability

http://www.fch-ju.eu/

Fuel Cells and Hydrogen
Joint Undertaking

DEMMEA (245156)

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

Maria Daletou

Advent Technologies

Aims of DEMMEA

The ultimate goal is to understand the degradation phenomena of a high temperature PEM fuel cell and make targeted modifications on the MEA system in order to increase performance and life time.

Main Objectives

- Understand the functional operation as well as the degradation phenomena of high temperature H_3PO_4 imbibed PEM.
- Understand the degradation mechanisms of Pt based electrocatalysts and of the 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.

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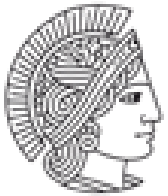
Advent

fumatech
Funktionelle Membranen und Anlagentechnologie

ICEHT/FORTH

PAUL SCHERRER INSTITUT
PSI



TECHNISCHE UNIVERSITÄT DARMSTADT

cnrs
dépasser les frontières

NEXT ENERGY
EWE-Forschungszentrum für Energietechnologie Oldenburg

INSTITUTE OF CHEMICAL TECHNOLOGY PRAGUE

- Four (4) EU members (France, Germany, Greece, Czech Republic) and Switzerland
- Five (5) Research organizations (FORTH, TUD, ICTP, CNRS, PSI)
- Two (2) SME (ADVENT, NEXT)
- One (1) Industrial partner (FUMATECH)

Strategy

- Polymer electrolytes of different chemical structures.
- Influence of the chemical structure on the oxidative stability and proton conductivity.
- New catalytic structures depicting lower corrosion and/or higher utilization of the catalyst.
- Use and development of in situ spectroscopic techniques for the study of the catalytic layer under fuel cell operation.
- SoA and new selected MEAs will be fully characterized by means of in situ measurements in respect to their degradation mechanisms.
- Development of a mathematical model describing platinum catalyst dissolution, movement and redistribution inside the cell.

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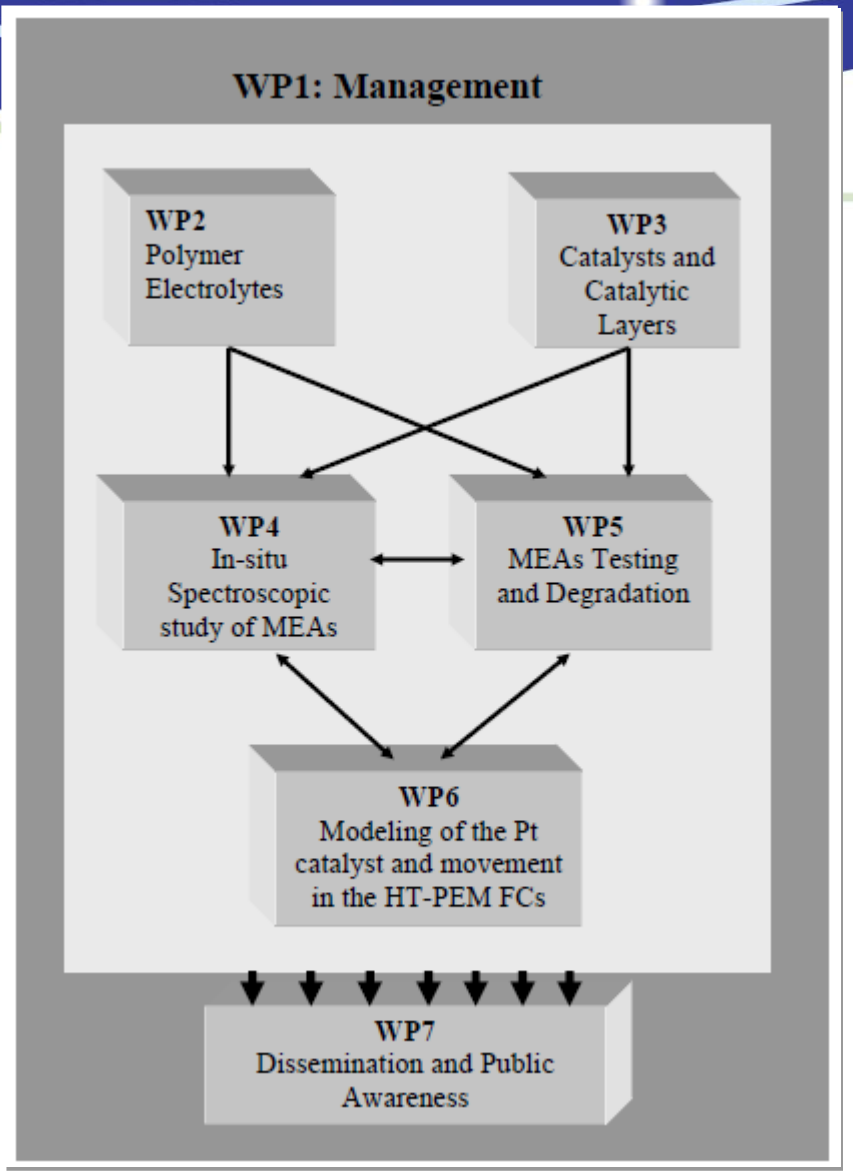
Selected Milestones

- Determination of the oxidation mechanism of the polymer membranes
- Chemical structure effect on proton conductivity.
- Preparation of well defined nanostructured supported catalysts.
- In situ spectroscopic characterization of the catalytic layer under fuel cell operation
- Determination of the mechanism that governs Pt dissolution, oxidation and agglomeration
- Evaluation of the results towards the understanding of the MEA failure mechanisms



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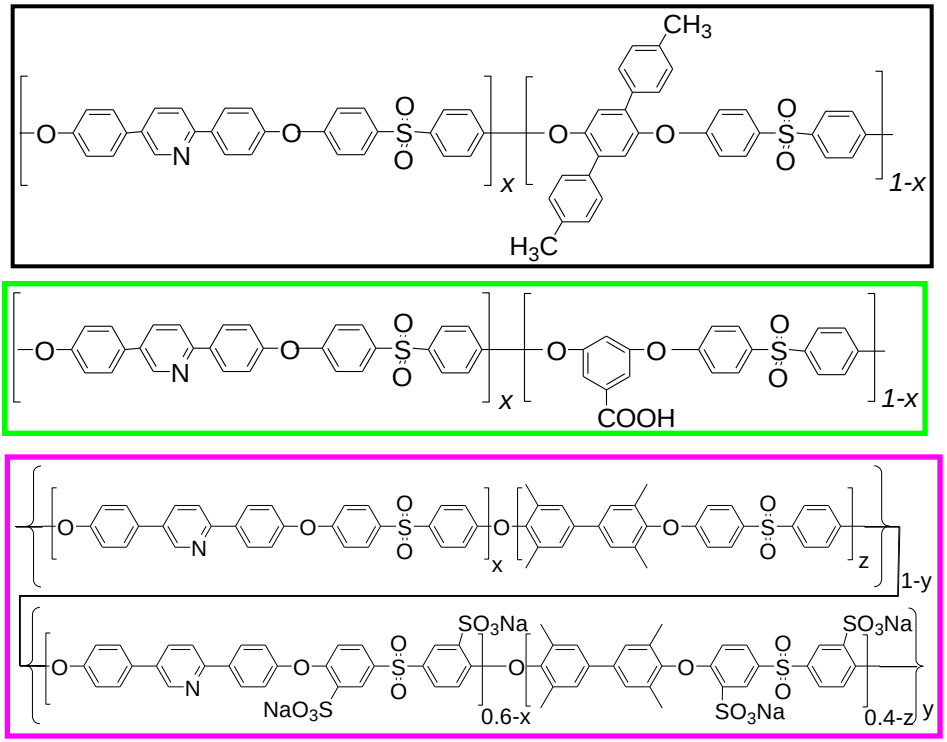
Polymer electrolytes

Synthesis of alternative chemical structures in order to get a deeper inside on its effect on their properties

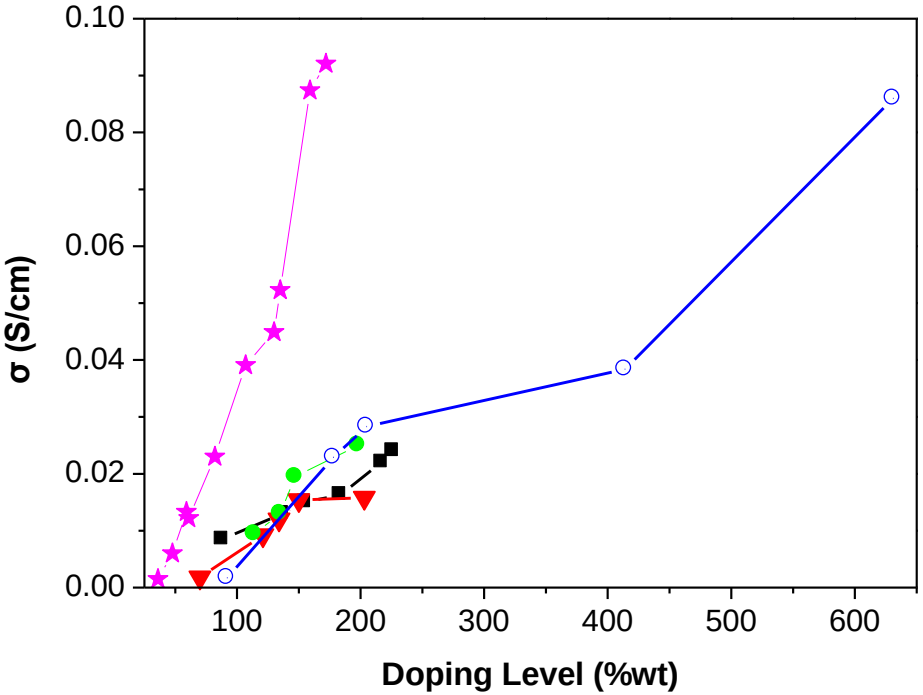


Terpolymer with carboxyl side groups

TPS

Conductivity vs side groups

Pyridine content *x~60*
@ r.t.



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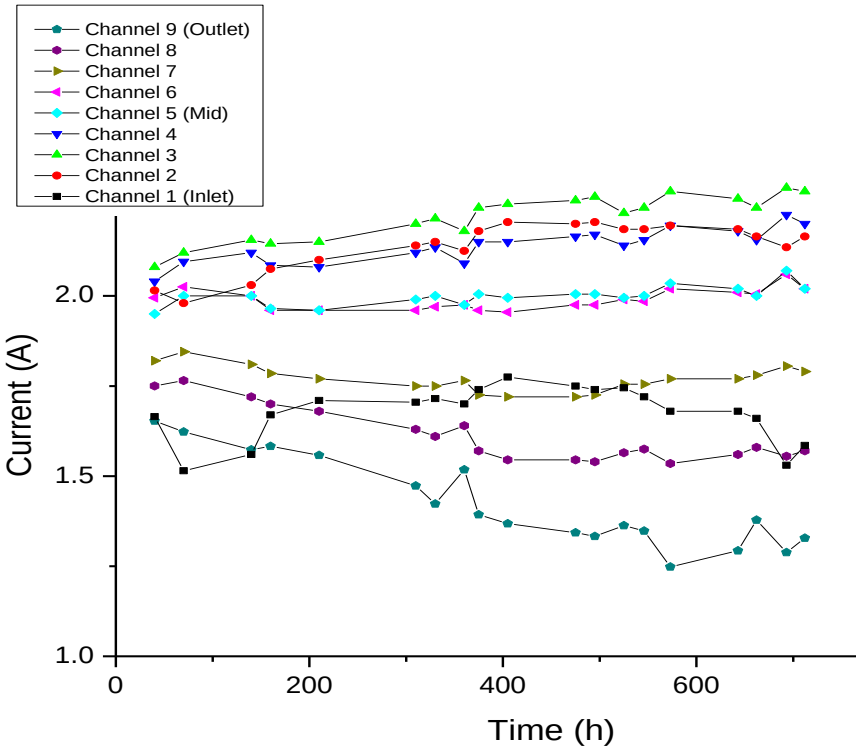
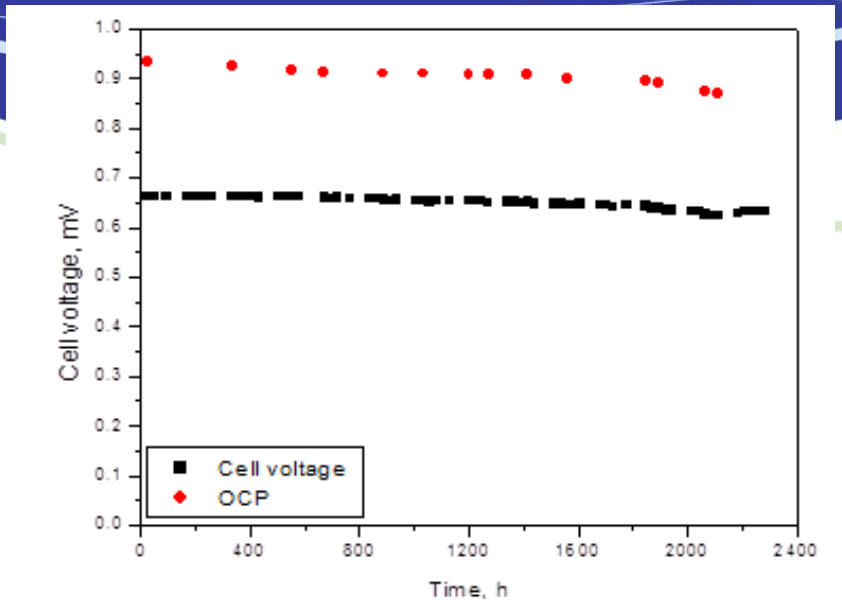
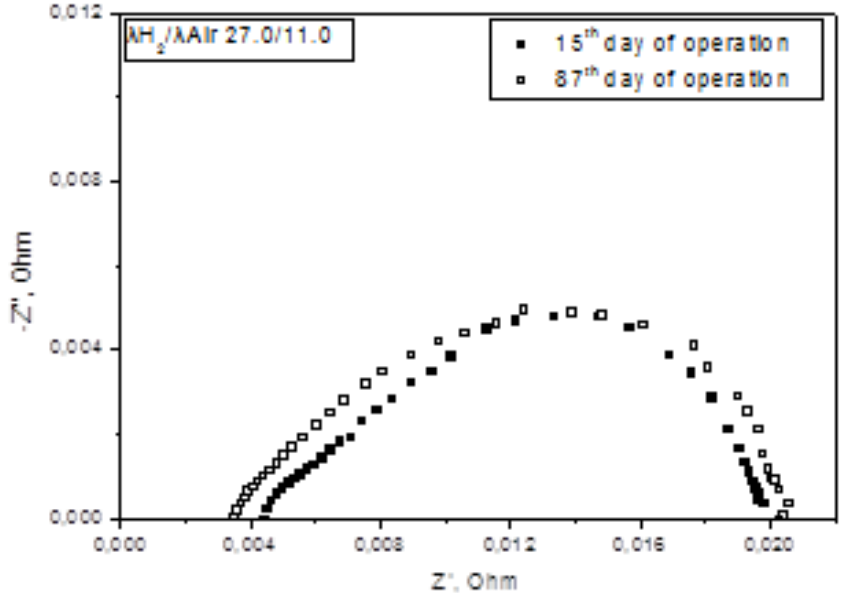
In situ diagnostic tools for MEA degradation

AC impedance spectroscopy
Electrochemically active surface area
Locally resolved measurements
Long term operation
Accelerated tests







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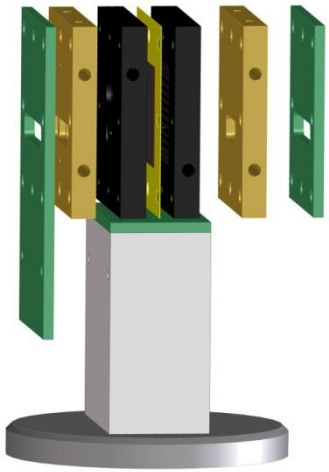
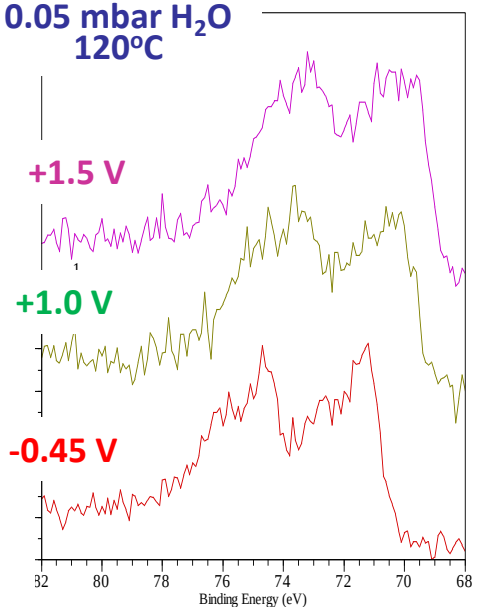
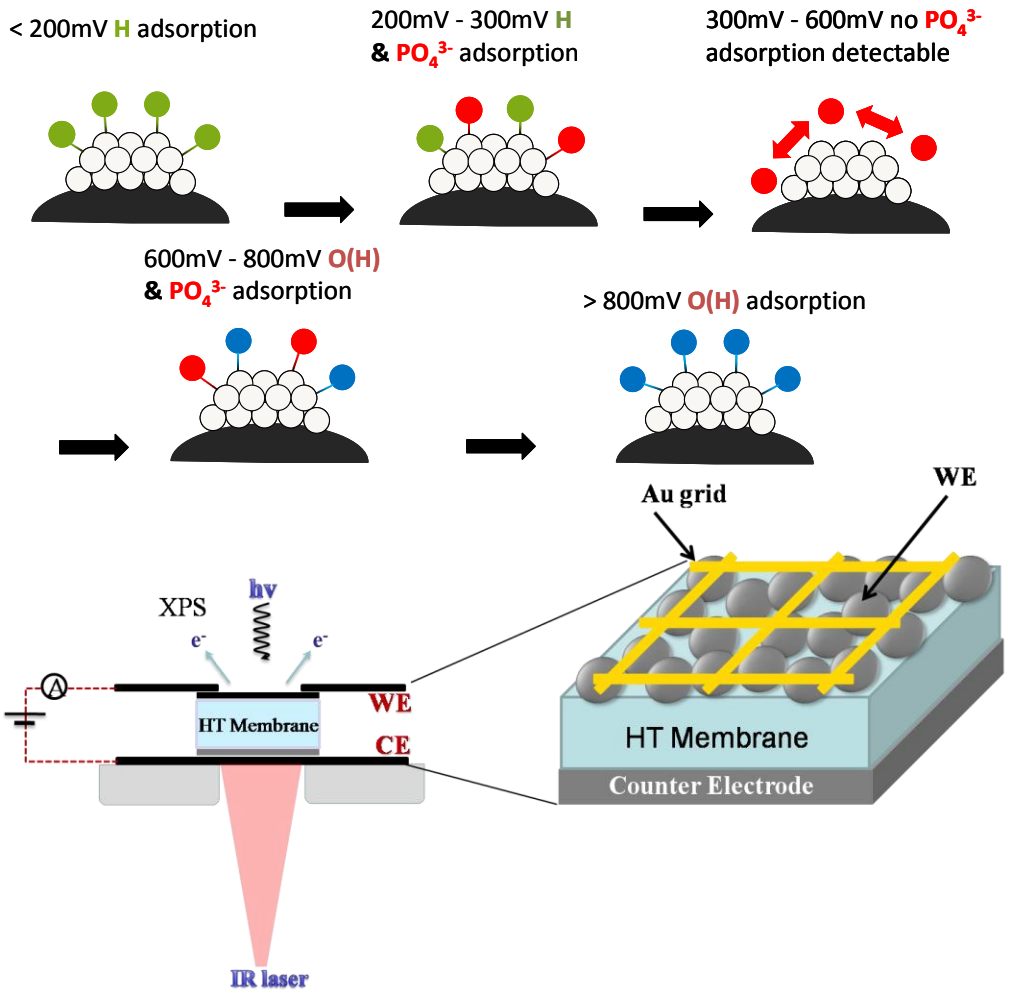
In situ spectroscopic measurements &high pressure XPS studies of the electrochemical interface







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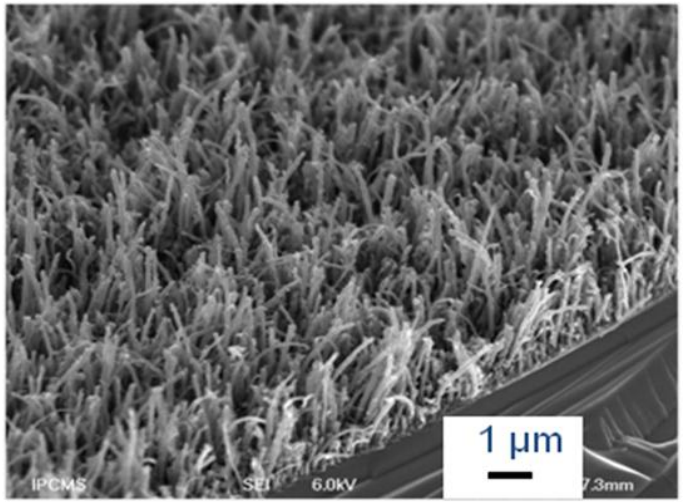
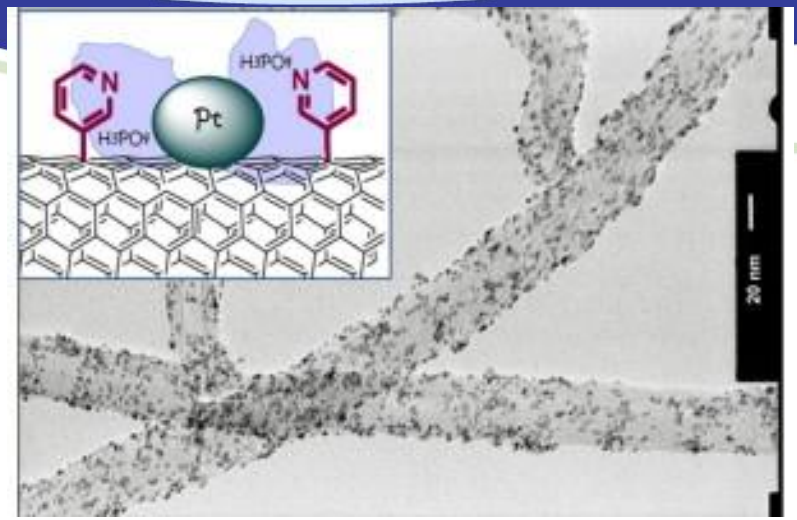
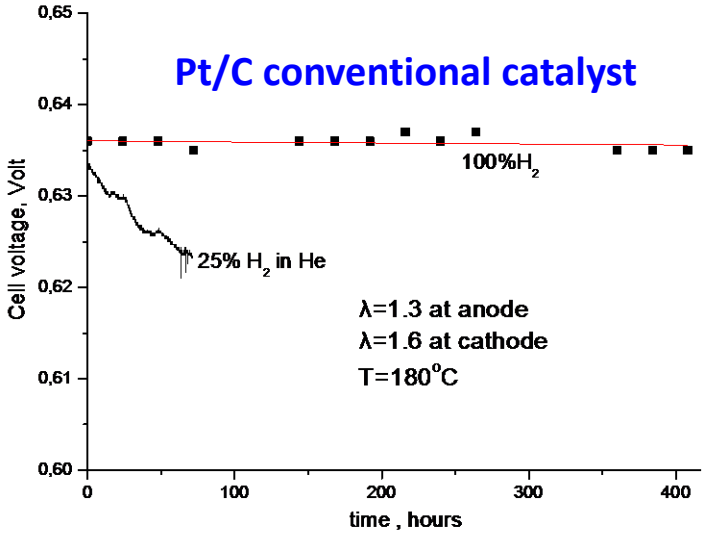
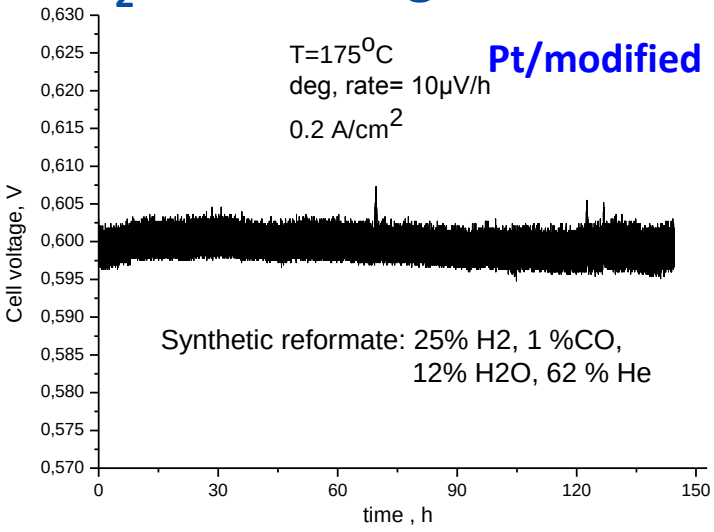




Stability test under lean H_2 reformate gas





Alignment to MAIP/AIP & Innovation

Principal output of DEMMEA

- **Development of characterization and control methodologies for PEM fuel cells,**
- **Understanding degradation and proton conductivity. Improvement of the novel state-of-the-art polymeric H_3PO_4 doped membranes based on aromatic polyethers with pyridine polar groups,**
- **Diminishing the degradation of the catalytic layer. Advanced design and synthesis of electrocatalysts and catalytic layer based on new structural architecture,**
- **MEAs manufacture, electrochemical characterization and long term testing of single cells.**

Alignment to MAIP/AIP & Innovation

- Standardization and harmonization of PEM fuel cells production and safety procedures.
- Production of reliable robust and less expensive high temperature polymer electrolytes.
- Low cost and highly efficient production of new advanced high temperature PEM fuel cell electrodes
- Low cost, robust and highly efficient MEAs as the key component for High Temperature PEM fuel cell applications.
- Validation of high performance for power densities exceeding 0.17 W/cm^2 at a cell potential of 700 mV (single cells).

Cross-cutting issues-dissemination

- The established contact between academia and high technology industry is capable to stimulate high level of scientific career opportunities. DEMMEA has already attracted the participation of young scientists whose advanced knowledge will benefit Europe .
- ADVENT (SME), NEXT (SME) and FUMATECH (Industry) ensure fast dissemination of the results that have already come out of the project through technology improvement that broadens their cooperation with industrial end-users.

Other dissemination activities & public awareness:

- 8 publications in peer reviewed journals
- Participation in 31 conferences and events
- 1 patent application
- Website dedicated to DEMMEA project (http://demmea.iceht.forth.gr)

Enhancing cooperation

Technology transfer:

✓**Highly interdisciplinary approach since the consortium consists of companies and academic institutes whose expertise cover a broad range of activities.**

✓**Interface with international and national research projects, e.g.:**

- **IRAFC -245202**
- **09-ΣΥΝ-51-453**
- **Eurostars E!5094**

Future perspectives

Exploitation of the system application in:

AUX power units
CHP units
Battery chargers with LPG (300 W)
Power supply in remote/off grid areas (2kW)
Telecommunications (5kW)
Regenerative fuel cells for space (3kW satellites)
Portable applications (70 W)
Stationary back up power systems

Thank you for your attention!