



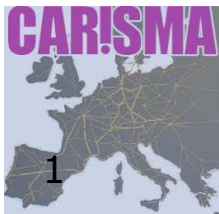
EUROPEAN
COMMISSION

Community research

Membrane development for medium and high temperature PEMFC in Europe

Deborah Jones

**CNRS - National Scientific Research Council,
University of Montpellier, France**





EUROPEAN COMMISSION

Community research

Funding for H₂/FC research in the EU

- European Commission has funded research on materials for fuel cells for over 20 years under 6 previous Framework Programmes

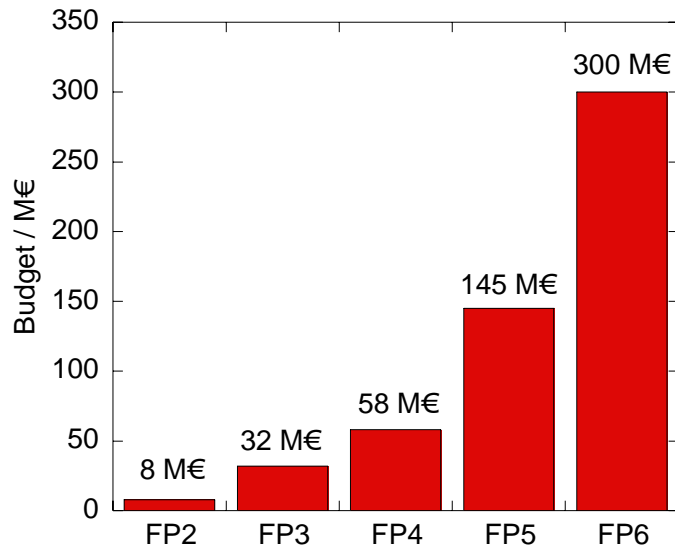
1982



1998 - 2002



2002 - 2006



- EC support to hydrogen and fuel cell RTD in Framework Programmes 2 to 6



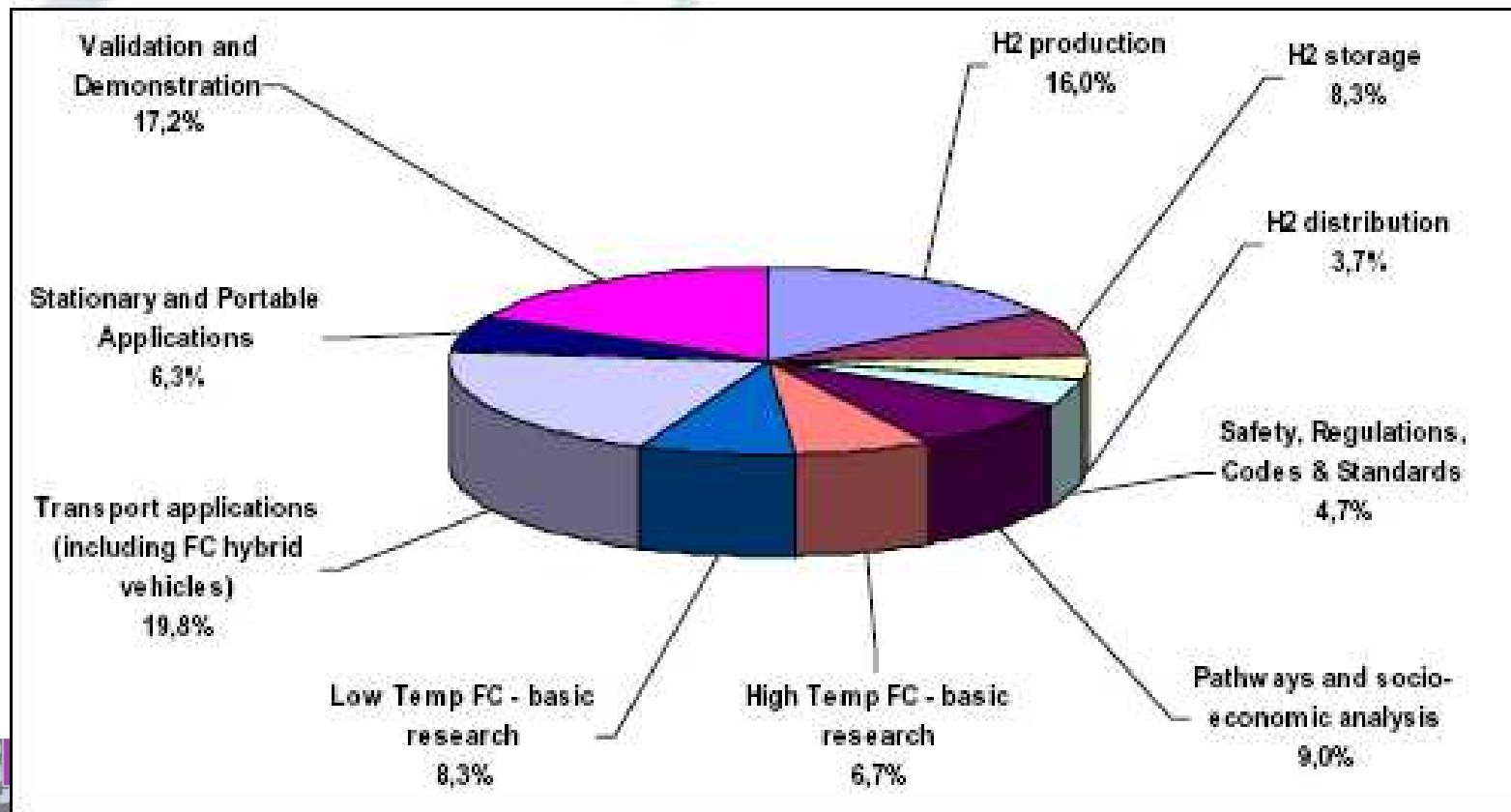


EUROPEAN
COMMISSION

Community research

FP6 Budget Breakdown for H₂/FCs

- Total EC Contribution to date ~300 M€



CARISMA



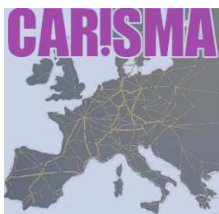


EUROPEAN
COMMISSION

Community research

FP7 2007 - 2013

Theme	Budget Breakdown (M€)
1. Health	6,050
2. Food, agriculture and biotechnology,	1,935
3. Information and Communication Technologies	9,110
4. Nanosciences, Nanotechnologies, materials and new production technologies	3,500
5. Energy	2,300
6. Environment (including Climate change)	1,900
7. Transport (including Aeronautics)	4,180
8. Socio-economic sciences and the Humanities	610
9. Space	1,430
10. Security	1,350
TOTAL	32,365





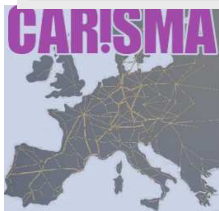
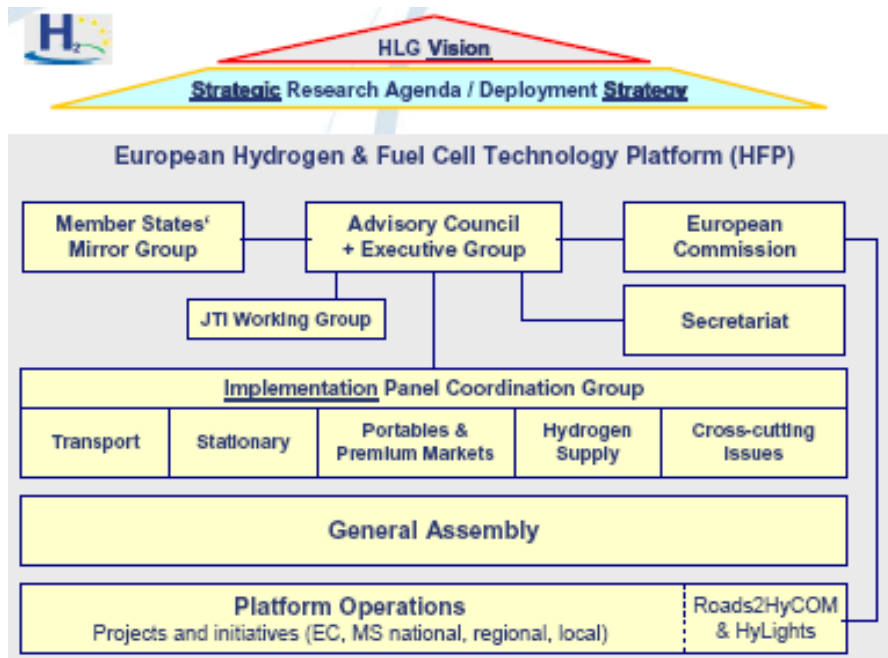
EUROPEAN COMMISSION

Community research

European Hydrogen and Fuel Cells Technology Platform

- HFP 2003 – 2007 (FP6)
Strategic Research Agenda
→ Implementation Plan

- For FP7, Joint Technology Initiative on Fuel Cells and Hydrogen, a Public-Private Partnership between Industry - European Commission – Research Organisations
- The JTI is a new management structure that will allow efficient organisation of the R&DD resources in Europe in fields of major European public interest and will have the necessary critical mass





EUROPEAN
COMMISSION

Community research

Fuel Cell materials projects funded under FP6

Acronym	Full Title	Aims	Coordinator	EC funding
FURIM www.furim.com	Further development and system integration of high temperature PEMFC	Developing advanced materials for a high temperature PEFC stack operating at nominally 170°C and integration into a fuel cell system	Technical University of Denmark	4 M€
Autobrane www.autobrane.eu	Automotive high temperature membranes	Research to raise the temperature of operation of the transport-application PEFC and to extend the range of humidity levels at which the MEA can operate	Daimler, Germany	8.3 M€
IPHE-GENIE	IPHE for the GENERation of novel IonomEr membranes	Association of IPHE partner countries outside Europe (in this case China and Russia) with Autobrane project	Energy research Centre of the Netherlands	0.7 M€
APOLLON-B	Development and testing of new high temperature polymer electrolyte membranes and fuel cell performance	Providing innovative solutions in efficient and low-cost high temperature PEM electrode assemblies.	Fn. Research and Technology Hellas, Greece (FORTH)	1,8 M€
PEMTOOL www.pemtool.net	Development of novel and validated software-based tools for PEM fuel cell component and stack-designers	Using mathematical analysis and rapid numerical software with experimental validation to develop efficient and verified software tools for PE FC development.	KTH, Sweden	1 M€
MOREPOWER http://morepower.gkss.de/mpower.html	Compact Direct (M)Ethanol Fuel Cell for Portable Application	Development of Direct Methanol Fuel Cells, including new polymer electrolyte materials for portable applications.	GKSS, Germany	2,2 M€
CARISMA www.carisma-network.eu	Coordination Action of Research on Intermediate and high temperature Membrane electrode Assemblies	Integration of European, national and regional basic and applied research and development efforts on high temperature PEFC Membrane Electrolyte Assemblies in order to substantially increase their impact.	National Scientific Research Council, CNRS, Montpellier, France	0,56 M€



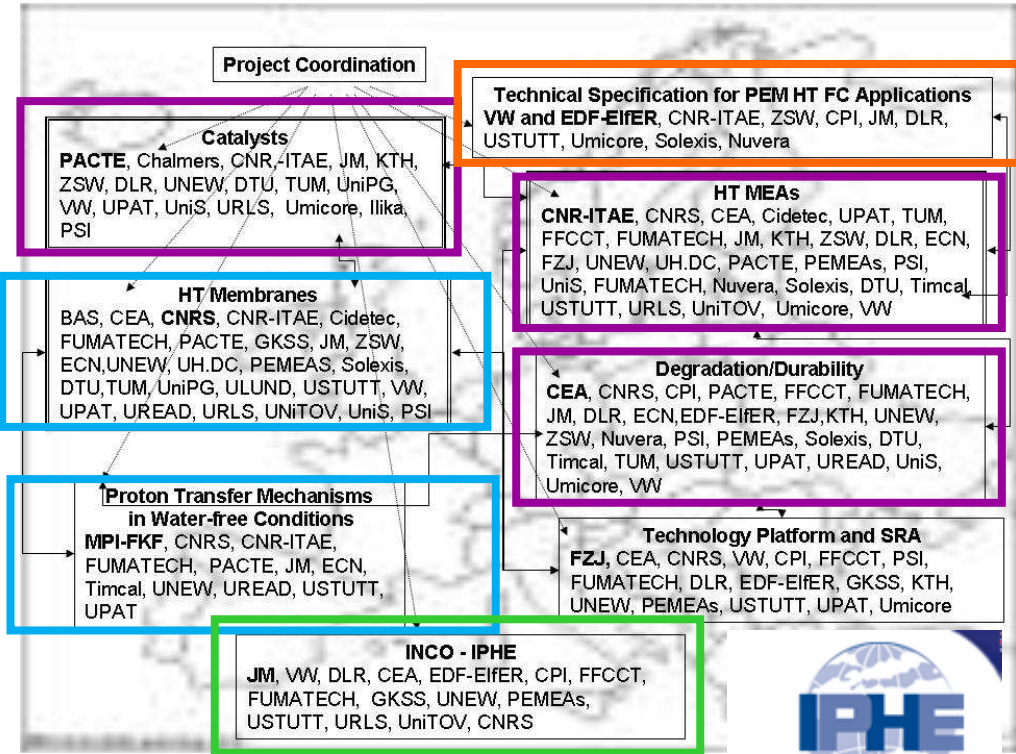
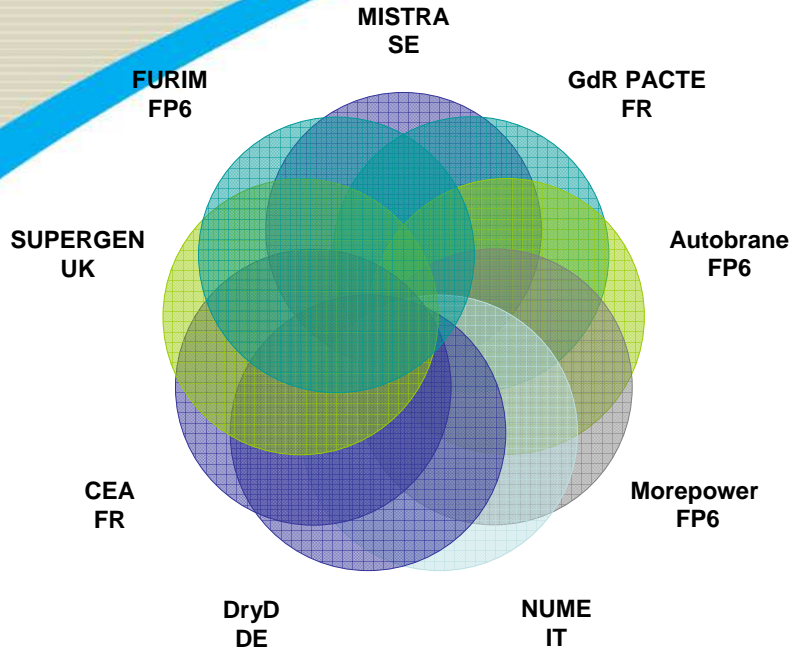


EUROPEAN COMMISSION

Community research

CARISMA coordination action

www.carisma-network.eu



Networking of funded groups and groupings
Medium and high temperature MEAs and their components

Framework for international cooperation
e.g. "High Temperature Membranes" project





EUROPEAN COMMISSION

Community research

www.carisma-network.eu

- [home](#)
- [about us](#)
- [activities](#)
- [ressources](#)
- [contacts](#)
- [links](#)
- [login](#)

About Carisma

The **Carisma European Coordination Action** is a forum for the **integration** of the research effort in Europe in the development of **high temperature MEAs for PEM fuel cells**. Integration and **interaction** between groups will be **enhanced** via a number of cornerstones that will underpin the R&D activities of the Coordination Action...

[Read more](#)



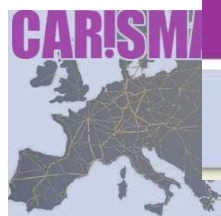
Membrane - Electrode Assemblies

CARISMA



Carisma News

- 19/09/2007 Agenda for the joint Carisma - HTMWG session, 10th October 2007, is now available...[Read more](#)
- 12/09/2007 First Carisma newsletter issue is now available...[Read more](#)
- 11/09/2007 International Summer School - *High Temperature Polymer Electrolyte Membrane Fuel Cells* - organised by the FURIM consortium...[Read more](#)
- 04/09/2007 Open positions at Paul Scherrer Institut...[Read more](#)
- 18/07/2007 Registration form for Carisma School on "proton transport mechanisms", joined with Carisma Workshop on "Ionomer Membranes for Medium and High Temperature PEM Fuel Cells"...[Read more](#)



Search the site :

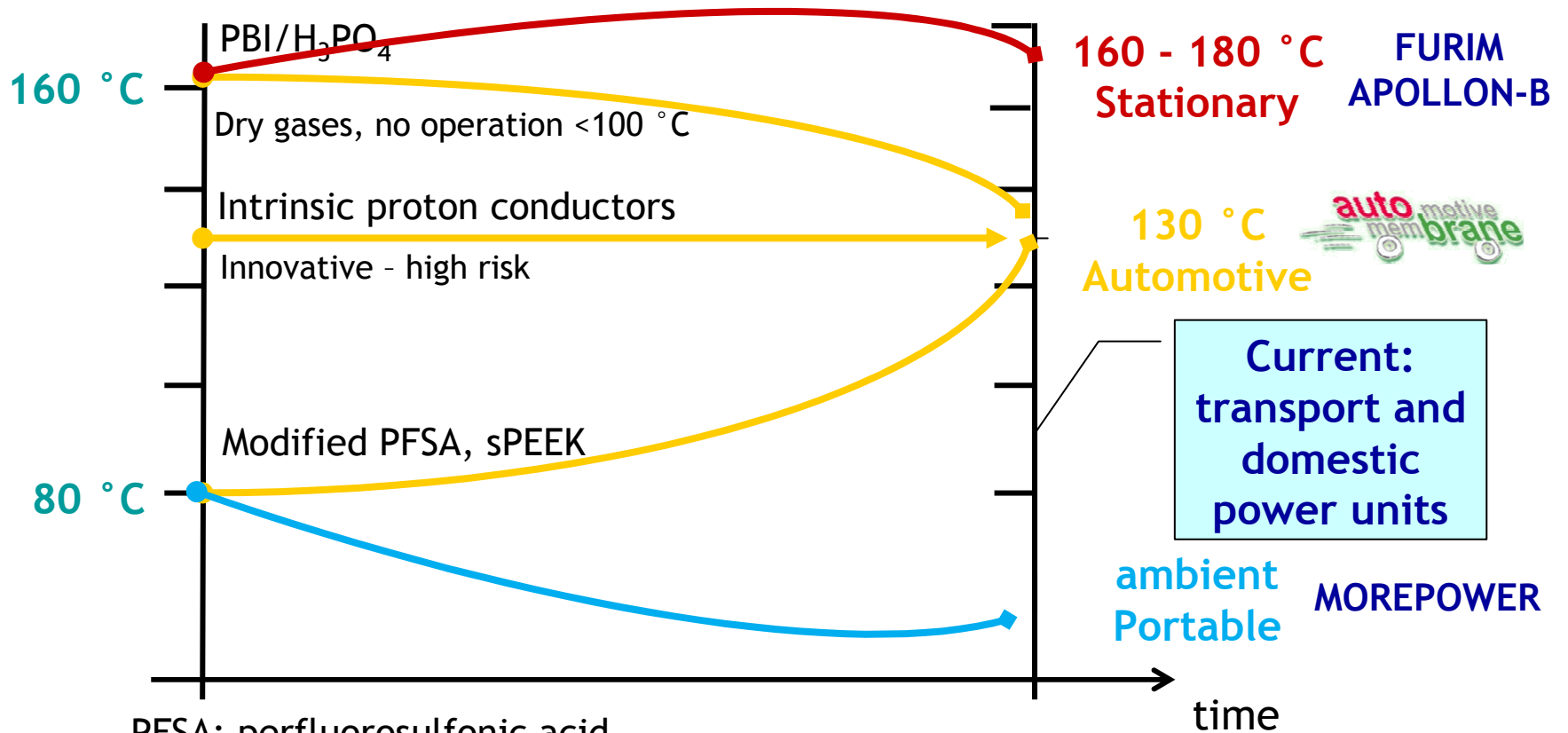
ok



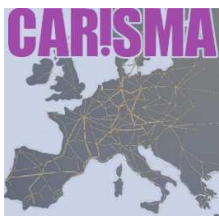
EUROPEAN COMMISSION

Community research

RTD approaches to new membranes in the EU



PFSA: perfluorosulfonic acid
 sPEEK: sulfonated poly(ether ether ketone)
 PBI: polybenzimidazole





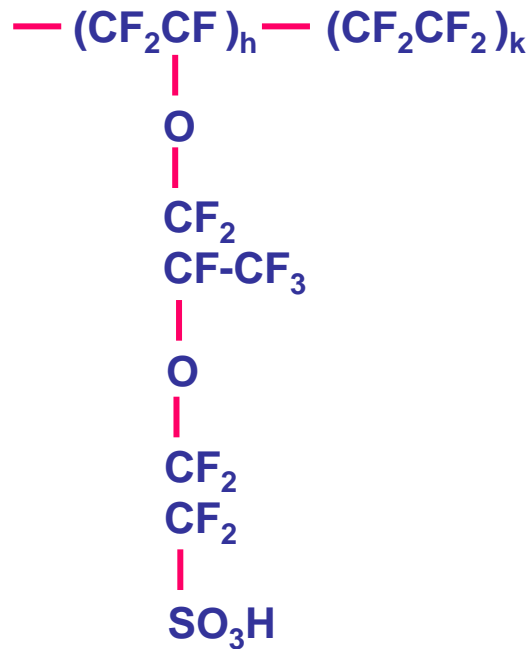
EUROPEAN COMMISSION

Community research

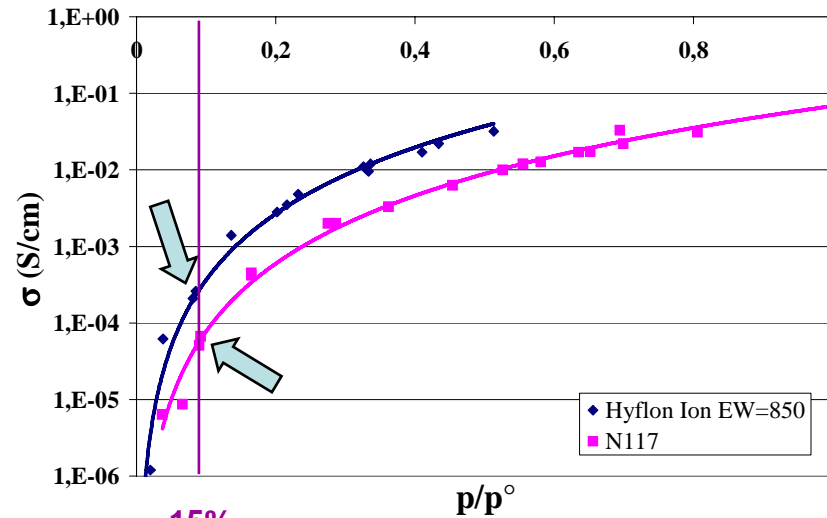
Autobrane perfluorosulfonic acid type polymers

- *Nafion*[®]

Short-side-chain ionomer



Long-side-chain ionomer



**PFSA polymers with
Low EW
High Tg**



Solvay-Solexis



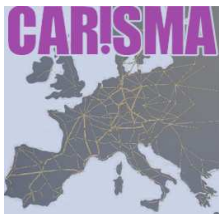
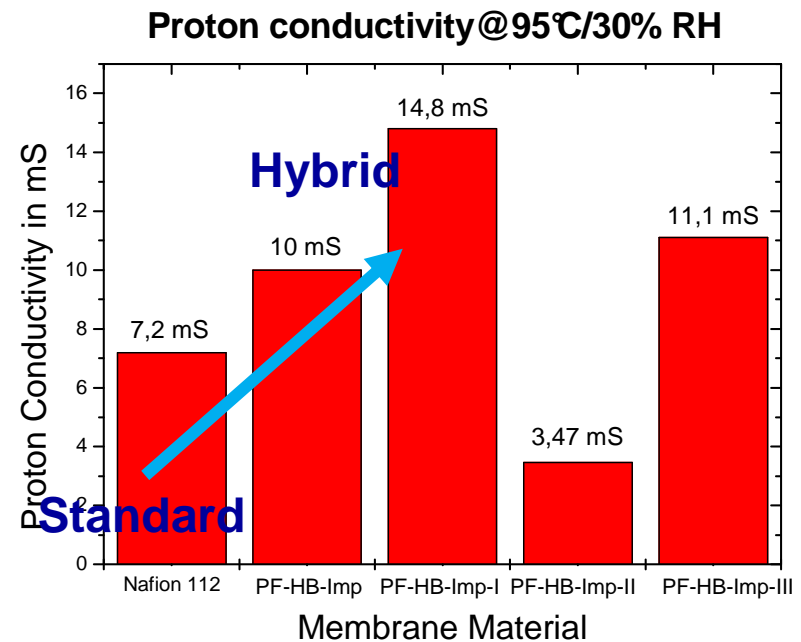
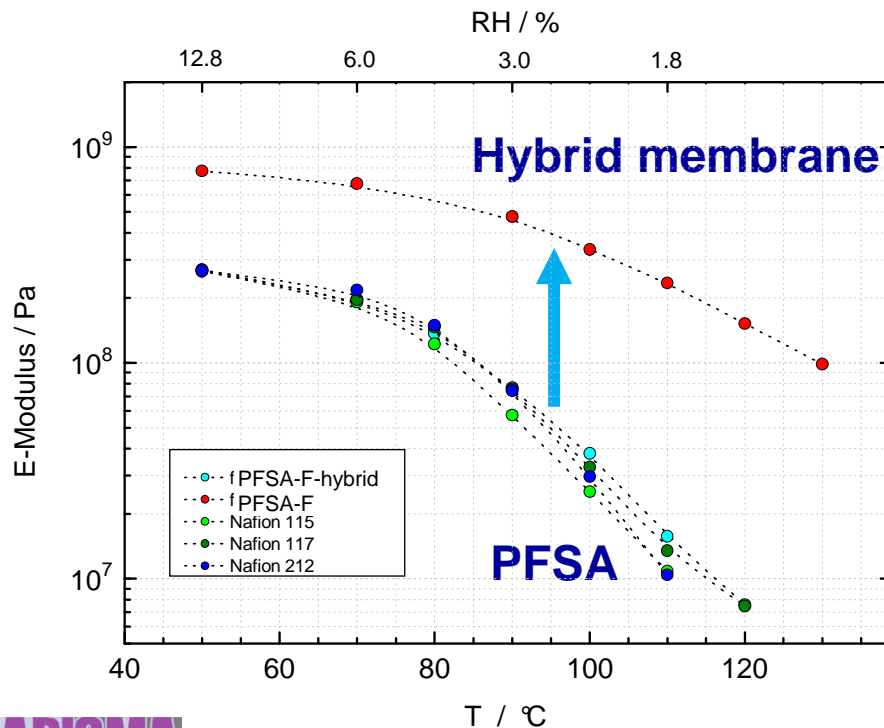


EUROPEAN
COMMISSION

Community research

Hybrid and composite membranes: Inorganic particles and networks

- Mechanical and proton conduction properties of hybrid inorganic-organic membranes: PFSA-type



FuMA-Tech
University of Perugia



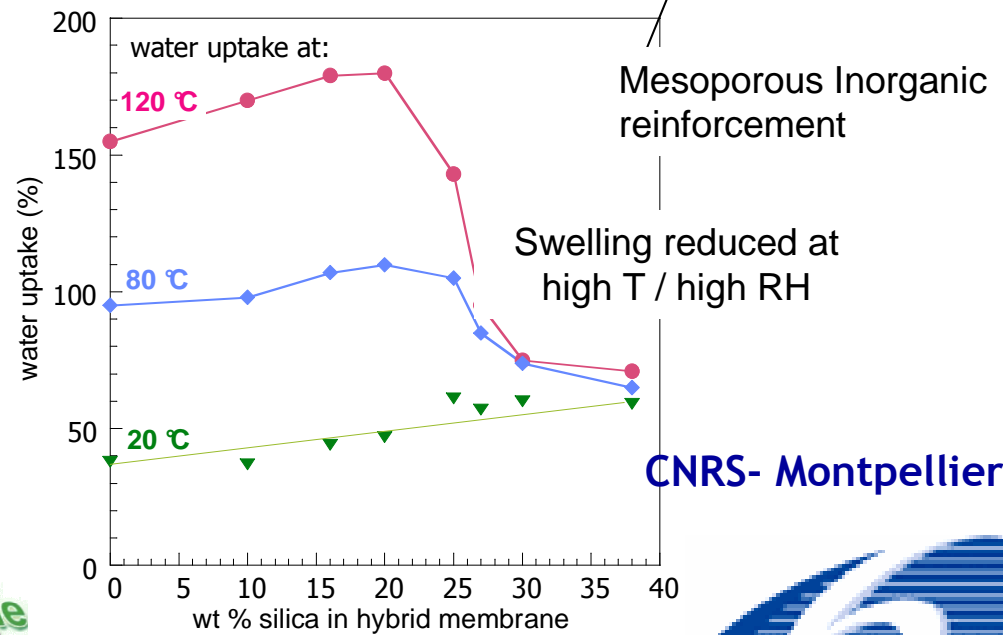
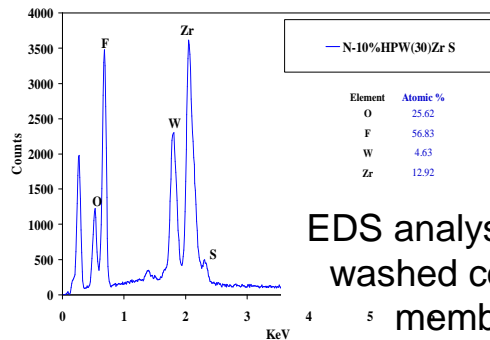
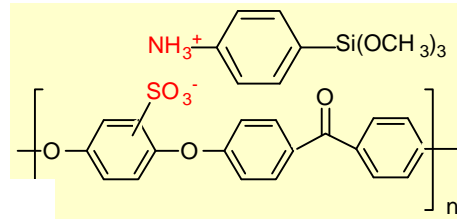
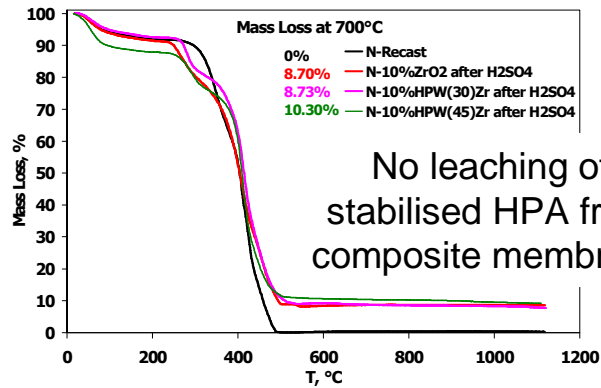


EUROPEAN COMMISSION

Community research

Hybrid and composite membranes: Inorganic particles and networks

Stabilisation of heteropolyacids



CNRS- Montpellier



CNR-ITAE
Messina



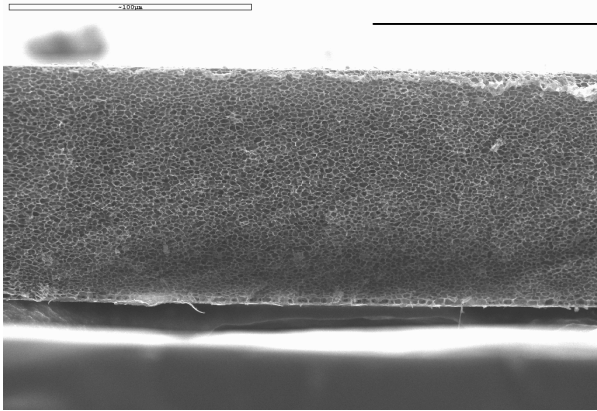


EUROPEAN
COMMISSION

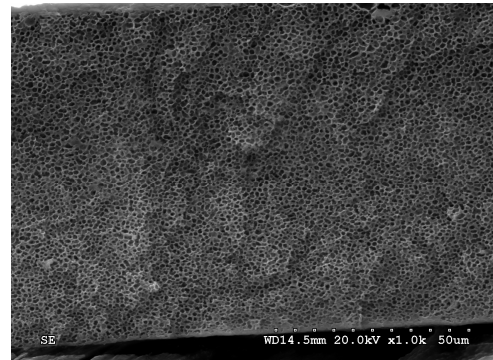
Community research

New processing methods for hydrocarbon-type sulfonic acid polymers

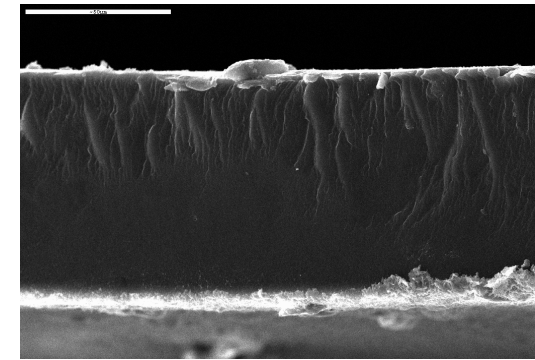
preparation conditions



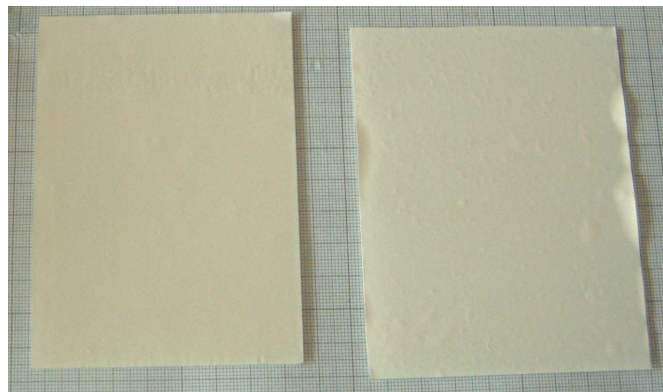
spherical pores of diameter 1 – 2 μm



spherical pores of diameter 0.4 – 0.8 μm

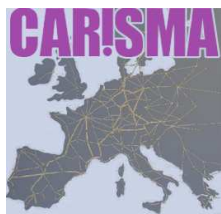


dense membrane

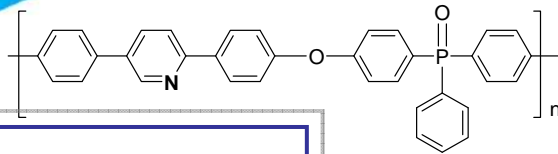


- Modified membrane morphology gives no change in dimension on dry/wet cycles

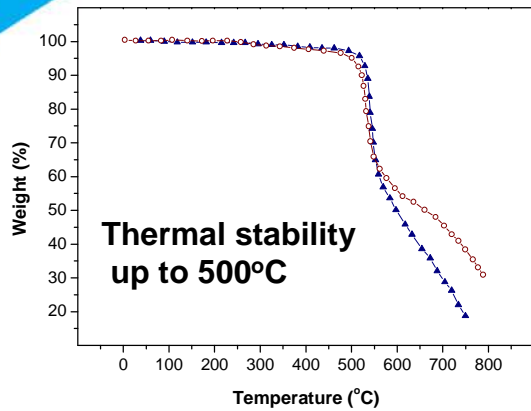
CNRS Montpellier



New polymer designs for acid doping

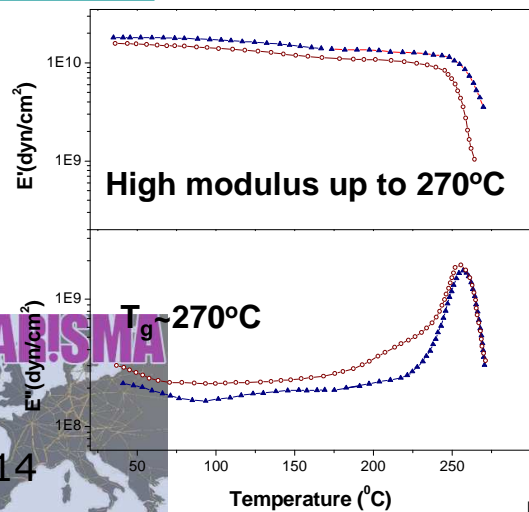


TGA



Before (—○—) and after (—▲—) treatment with H₂O₂

DMA

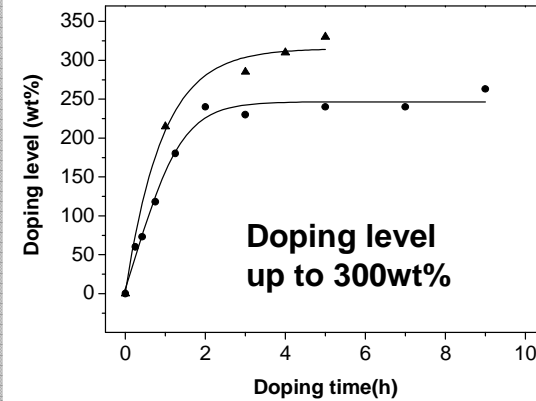


Combined Properties

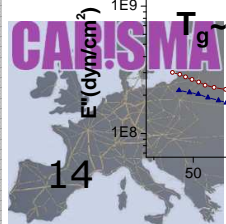
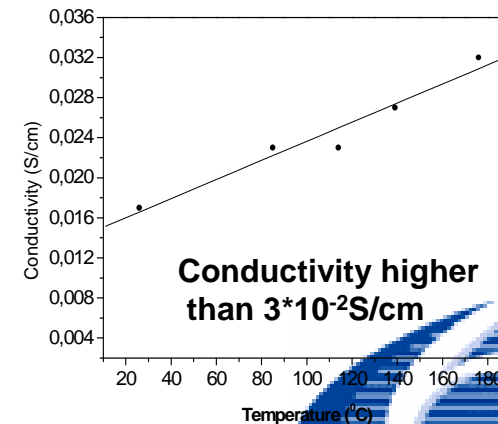
- Solubility
- Film forming properties
- High molecular weight
- High proton conductivity
- Thermal/Chemical Stability
- High T_g
- High Membrane Quality
- Easy Handling for MEA preparation

**APOLLON-B
FORTH (GR)**

Doping level With H₃PO₄



Conductivity measurements



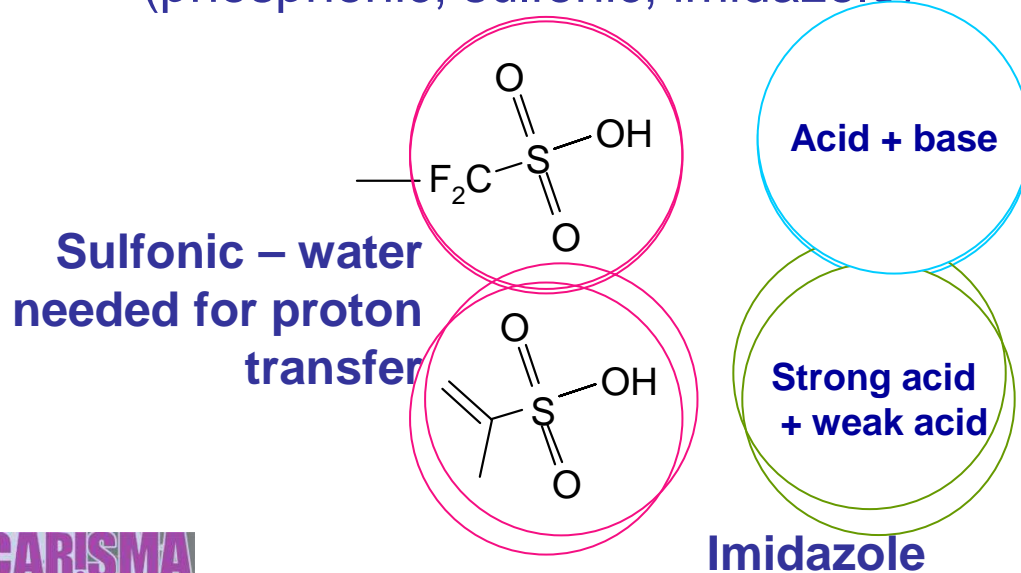


EUROPEAN
COMMISSION

Community research

New polymers, new functions

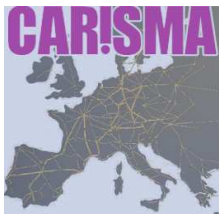
- New polymers functionalised with sulfonic or phosphonic groups (phosphonic, sulfonic)
- Innovative approaches to proton conducting membranes using novel protogenic functions and interpenetrating network structures (phosphonic, sulfonic, imidazole)



Phosphonic – quasi-anhydrous, some water needed

Combinations of polymer types to draw best advantage from each

Blends and interpenetrating networks



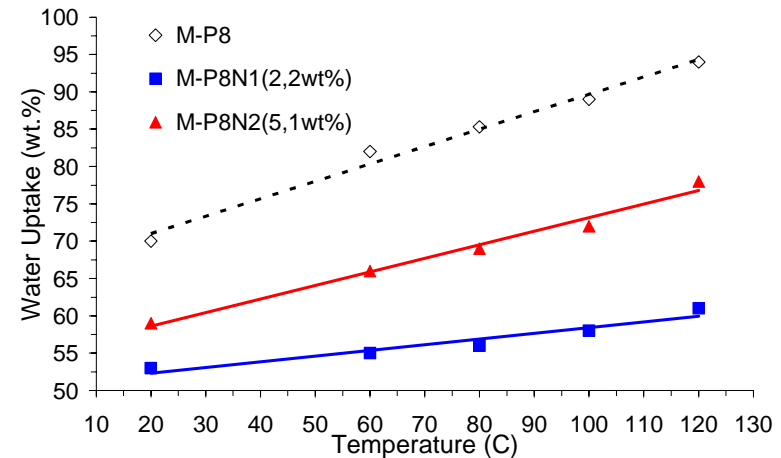
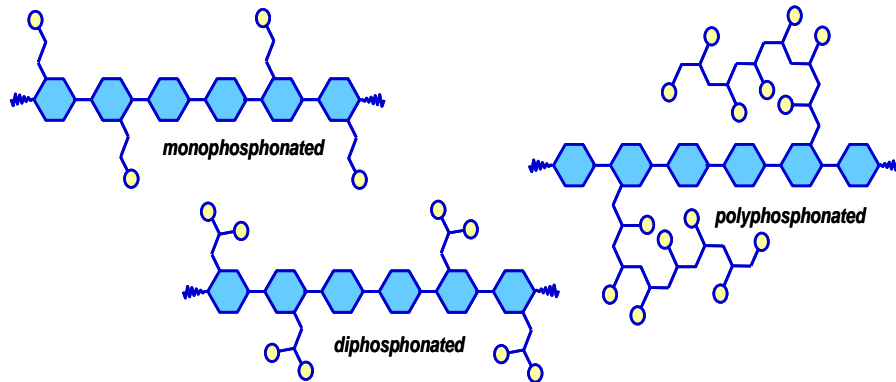


EUROPEAN
COMMISSION

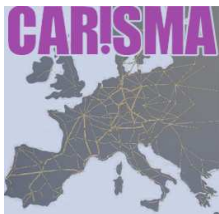
Community research

New thermostable polymers with high degrees of functionalisation

- Polyphosphonated thermostable polymers



University of Lund



HTMWG - CARISMA joint session 10th October 2007

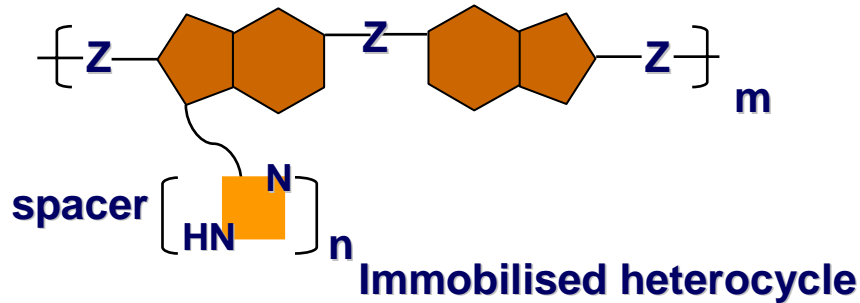




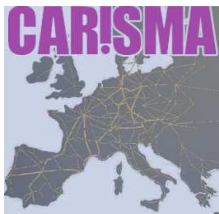
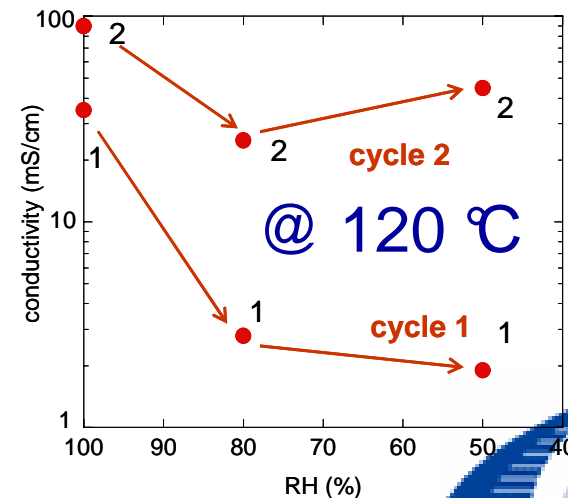
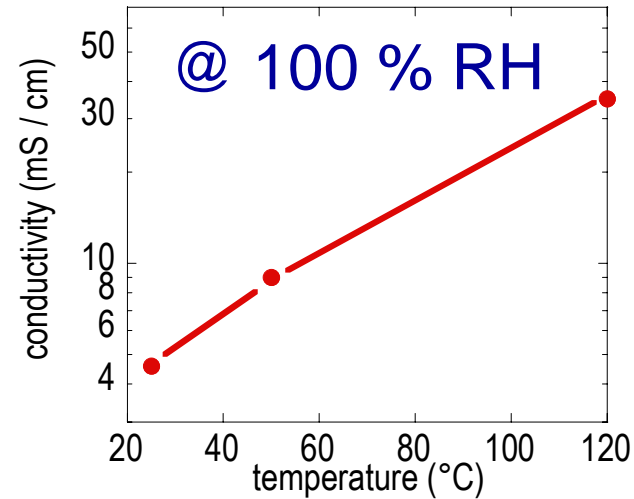
EUROPEAN COMMISSION

Community research

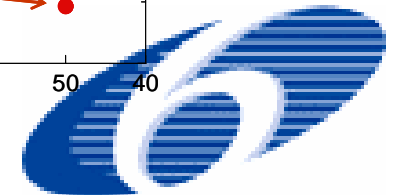
New thermostable polymers with high degrees of functionalisation



"Immobilised solvent" – proton conducting heterocycle solvents tethered to polymer backbone



CNRS

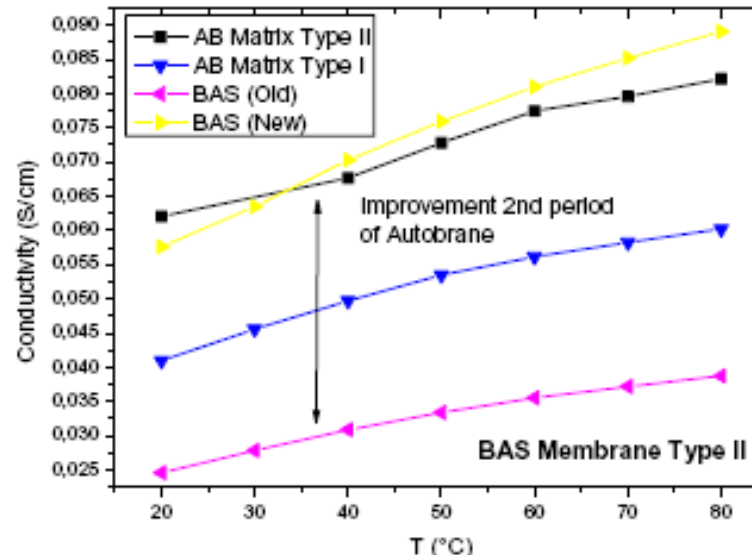
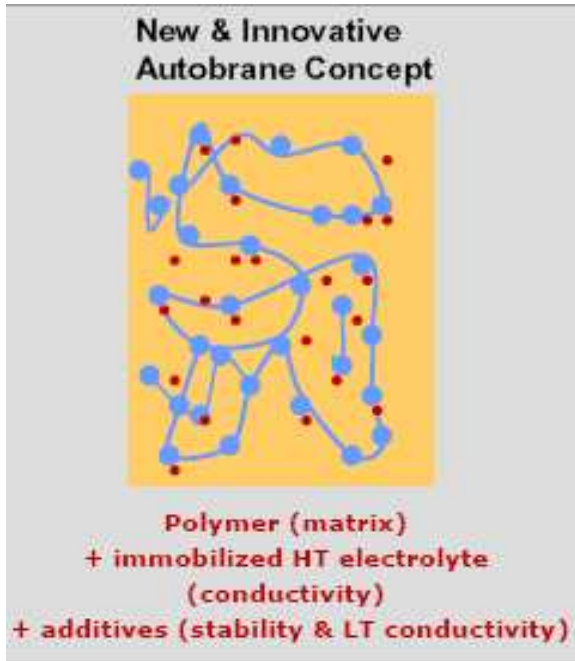




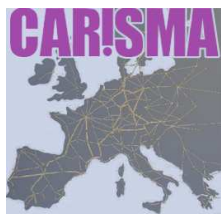
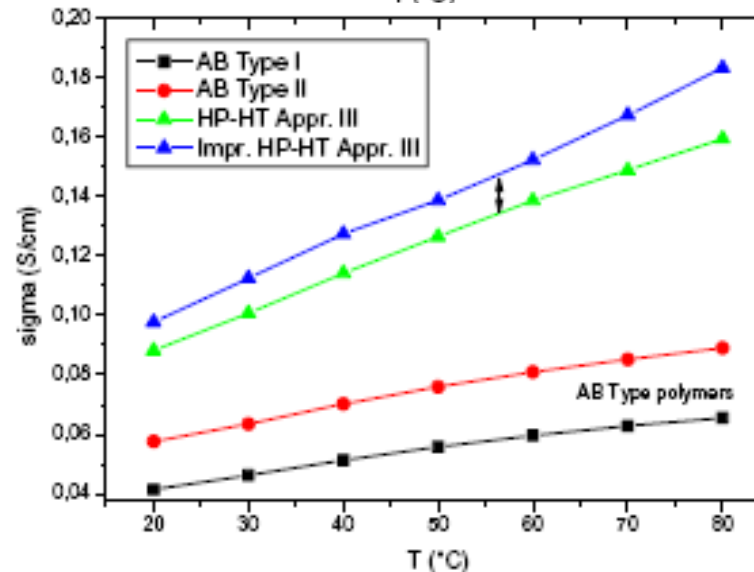
EUROPEAN COMMISSION

Community research

Blends and interpenetrating networks



Testing under fully humidified conditions in wet cell (liquid H₂O), 4-pole measurements



BASF

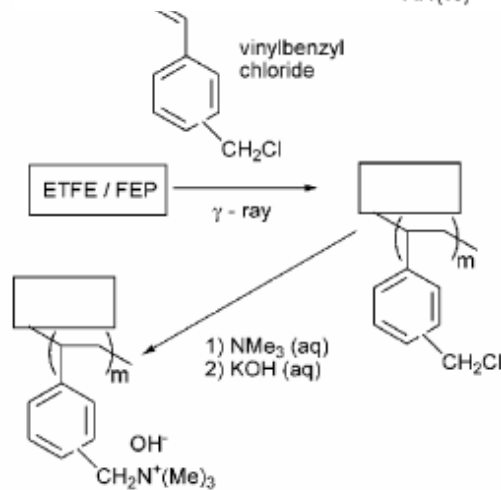
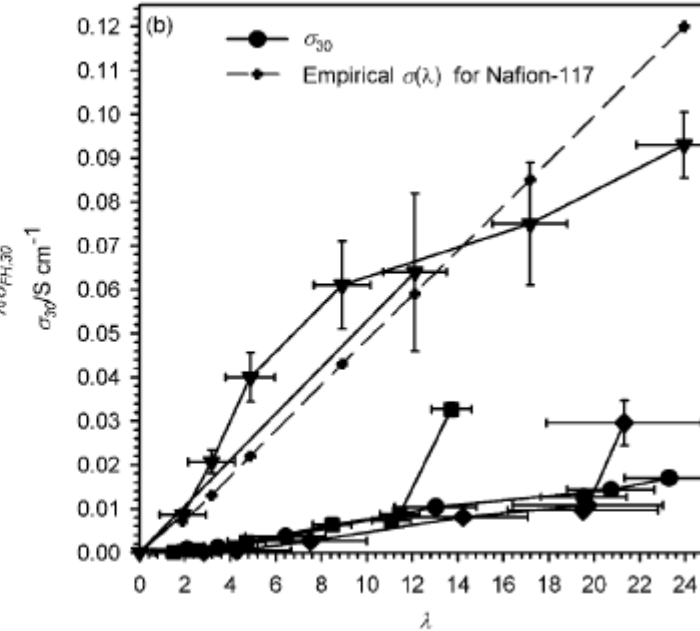
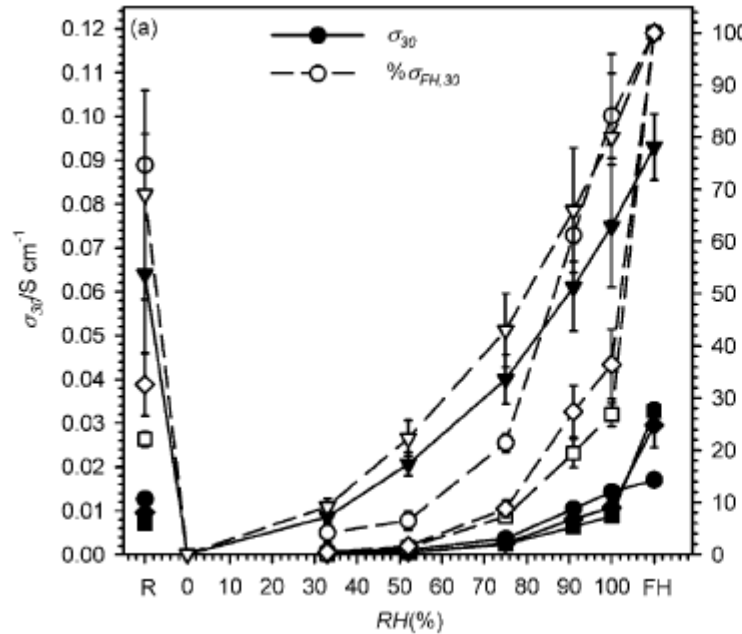




EUROPEAN COMMISSION

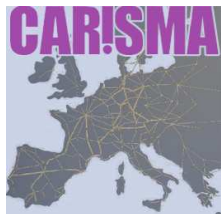
Community research

Alkaline PEFC membranes



- ◆ High pH \Rightarrow more facile kinetics
 - Cheap metal catalysts at anode & cathode
- ◆ Reduced methanol transport
 - OH⁻ ion transport from cathode to anode
- ◆ Reduction in cathode flooding (DMFC)
 - Water supplied & consumed at cathode

J. Varcoe, R. Slade, University of Surrey



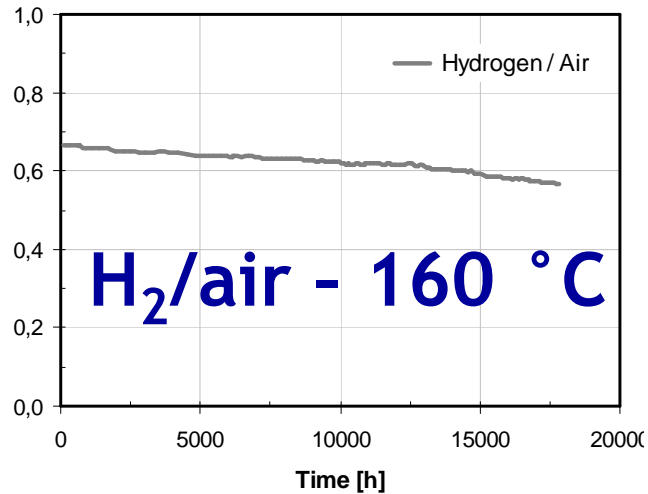


EUROPEAN COMMISSION

Community research

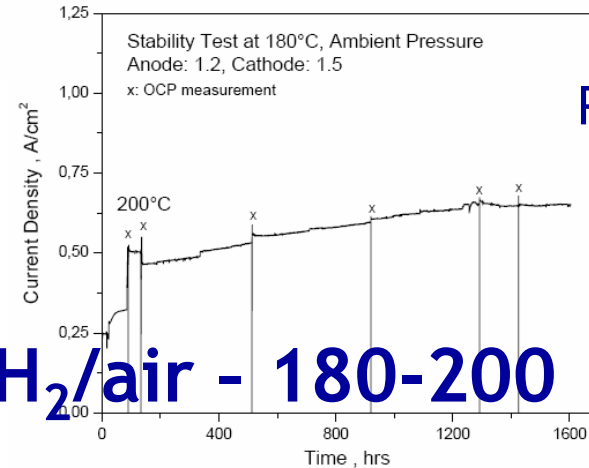
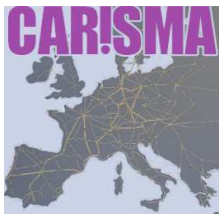
Durability: steady state operation

Celtec-P1000



- 20,000 h steady state operation
- 160 °C, 0.2 A/cm²
- voltage drop < 6µV / h

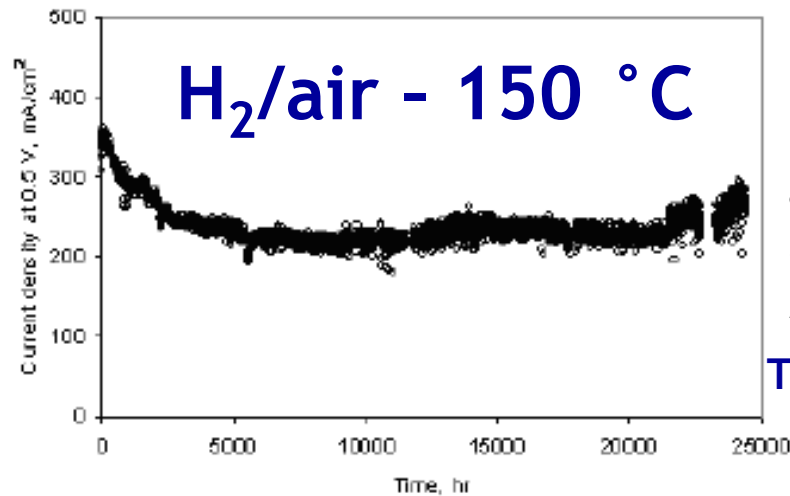
BASF



APOLLON-B Poly (PPEP)-H₃PO₄

- Continuous operation at 0.5 V and 180-200 °C

FORTH



FURIM PBI-H₃PO₄

- Continuous operation at 0.5 A/cm², 150 °C

Tech.Uni.Denmark

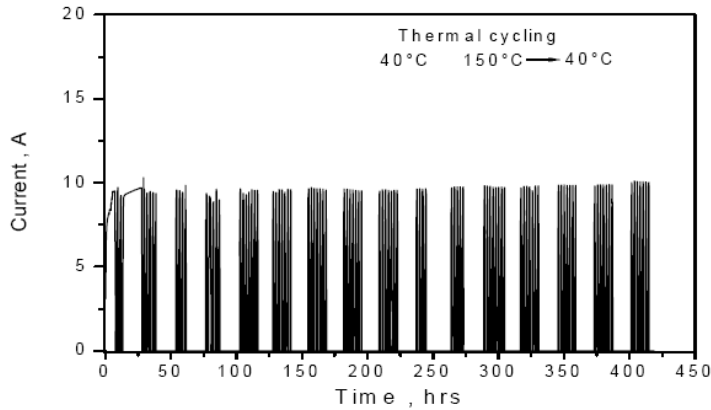




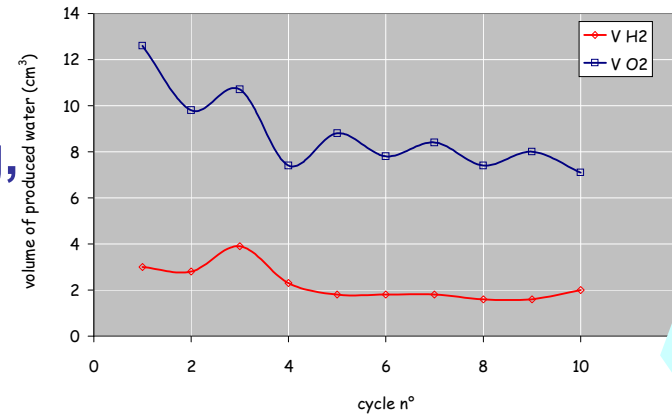
EUROPEAN COMMISSION

Community research

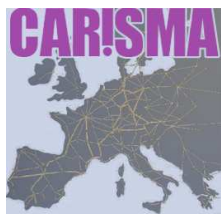
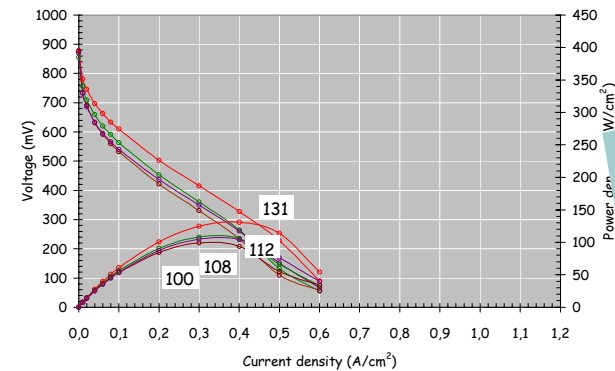
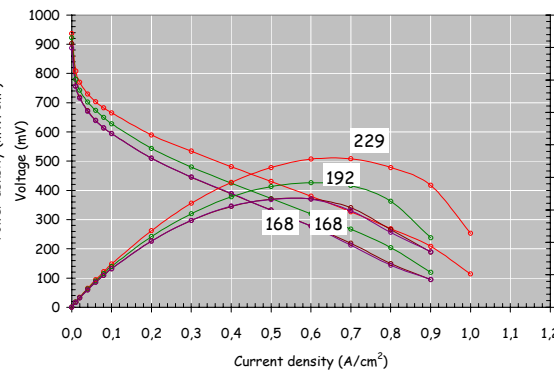
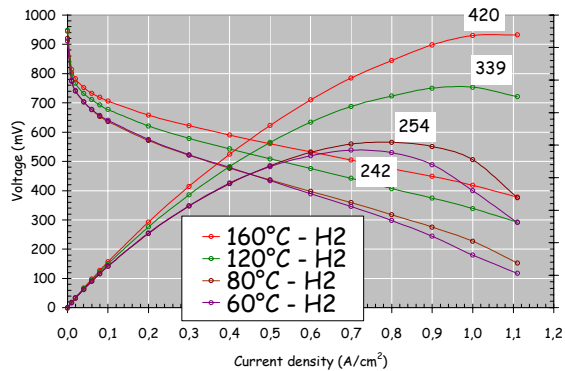
Durability Start/stop, thermal cycling



APOLLON-B:
Thermal cycling,
no load at low temperature



Celtec-P1000: trigger liquid water failure mode by inducing degradation



Temperature cycle from 160 to 60 °C under 0.4 A/cm²

CNRS-BASF-EDF





EUROPEAN
COMMISSION

Community research

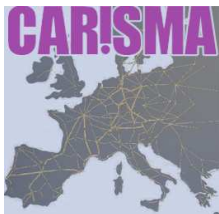
Perspectives and Opportunities

Perspectives (Membrane)

- Pursue development of new membrane materials – with high and low temperature conductivity, at high and low relative humidity – satisfying operation protocols for transport and stationary applications
- Pursue development of medium-high temperature membranes for alternative fuels
- Develop and pursue collaborations to enable robust sets of characterisation techniques to validate preparative strategies

Challenges (Membrane)

- Durability, Impact of MEA degradation products, Scale-up feasibility, Reproducibility, Feasibility of MEA development with new membranes, Cost





EUROPEAN
COMMISSION

Community research

Acknowledgments

- CARISMA is funded by the European Commission under contract 039041

