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**P E M - E D**



## ***Proton Exchange Membranes for Application in Medium Temperature Electrochemical Devices***

**Coordinator:** FuMA-Tech GmbH  
(Germany)

**Contact point:** Dr. Bernd Bauer

**Contract** N° ERK6-CT-1999-00025

**Start:** March 2000

**Duration:** 48 month



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# PEM-ED



**Scotland**

University of Strathclyde

**Germany**

FuMA-Tech GmbH

IFEU GmbH

**The Partnership:**

9 partners from 5 countries

5 industries

2 universities

2 research organisations

**Switzerland**

SEFAR AG

**France**

Electricité de France

CNRS Montpellier

**Italy**

NUVERA s.r.l.

Università degli Studi di Perugia

CNR Messina



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## Industrial Partners

- FuMA-Tech GmbH
- NUVERA Fuel Cells
- IFEU GmbH (Institut für Energie- und Umweltforschung GmbH)
- Electricité de France (Division Recherche et Développement, Service Matériel Electrique)
- SEFAR AG (Filtration Division)



## Universities and Research Organisations:

- CNRS Montpellier  
Centre National de la Recherche Scientifique  
Laboratoire des Agrégats Moléculaires et Matériaux Inorganiques
- CNR-TAE Messina  
Consiglio Nazionale delle Ricerche  
Istituto di Ricerche sui Metodi e Processi Chimici per la Trasformazione e l' Accumulo dell' Energia
- Università degli Studi di Perugia  
Dipartimento di Chimica, Laboratorio di Chimica Inorganica
- University of Strathclyde  
Department of Pure and Applied Chemistry



Dr. Bernd Bauer (FuMA-Tech GmbH)



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## Main Objectives of PEM-ED

- **New protonic materials**
  - stable up to 180 °C
  - having a conductivity preferably  $10^{-3}$ - $10^{-1}$  Scm<sup>-1</sup>
- **Based on**
  - sulfonated polymers
  - hybrid inorganic-organic systems

### State-of-the-Art:

Solid state protonic conductive materials currently known are suitable in temperature ranges either **below 80°C** or **above 800°C** !



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## Major Problems to be solved within PEM-ED

### Case 1:

- Proton conductivity at medium temperature and low humidities (< 30 % r.h.)

### Case 2:

- Proton conductivity at high temperature and zero humidification

### Expectations into cost-reduction of fuel cells:

- enhanced CO tolerance of the MEA
  - easier heat and water management of the system
- Simplification of the powertrain



## Desired Properties of Membranes for HT fuel cells

- **Chemical mechanical and electrochemical stability**
- **High proton conductivities**
- **Extremely low permeability to gases**
- **Excellent water management**
- **Production costs compatible with application (mobile, stationary, portable)**
- **Chemical properties compatible to MEA bonding requirements**
- **Recyclable (no fluoride)**

### FUEL CELL BATTERIES

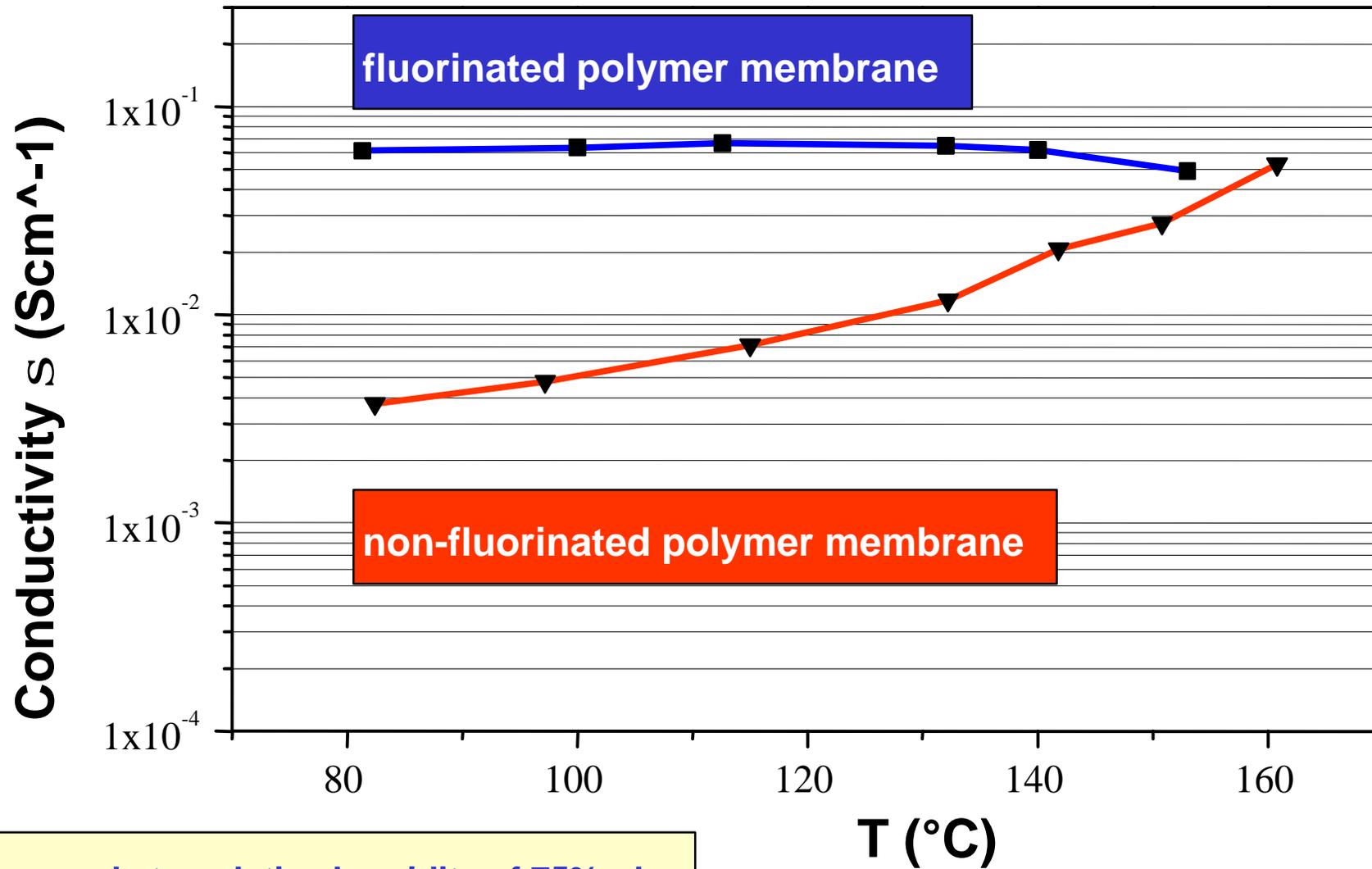
- **Suitable for high temperatures (90°C → 130°C → 165°C)**
- **Self humidification**
- **High conductivities at low relative humidity or even dry membrane**



## State-of-the-Art in medium temperature fuel cells

- **Sulfonated non-fluorinated polymers**
  - strong humidification necessary
  - deactivation of sulfonic acid groups at  $T > 160 \text{ }^\circ\text{C}$
- **Phosphoric acid fuel cells with immobilized electrolyte**
  - $\text{H}_3\text{PO}_4$ - doped polybenzimidazoles
  - loss of electrolyte (corrosion)
  - low conductivity at  $T < 120 \text{ }^\circ\text{C}$
- **Inorganic zirconium phosphate proton conductors**
  - no remarkable proton conductivity at  $T < 250 \text{ }^\circ\text{C}$

Novel approach (first R&D initiated in 1994)  
**Hybrid inorganic-organic systems based on sulfonated  
polymers and inorganic phosphonates**



Measured at a relative humidity of 75% r.h.



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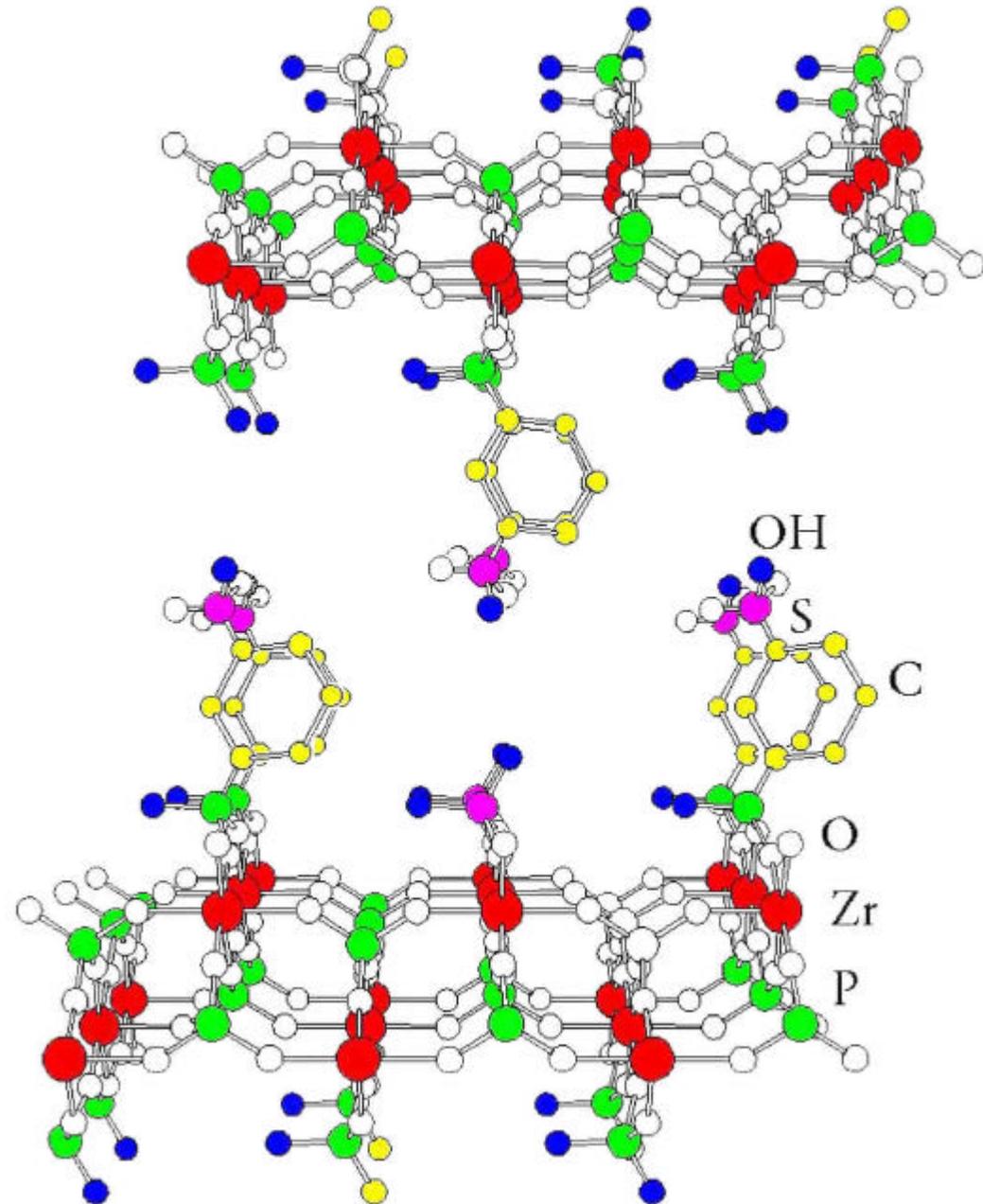
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Schematic representation  
of the structure of  
gamma zirconium  
sulfophenylphosphonate,  
a proton conductor that  
can be used as a  
component of  
hybrid proton conducting  
membranes







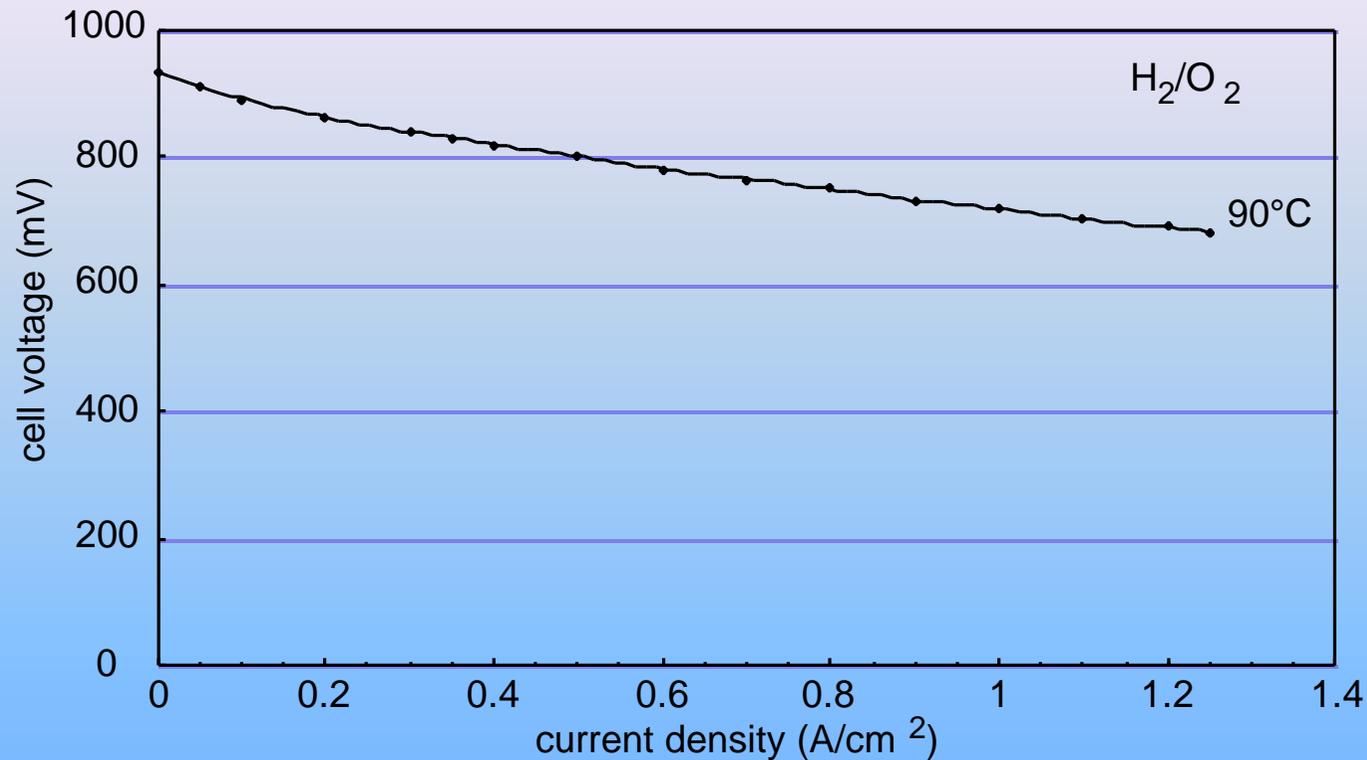
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Hybrid Membrane (1,96 meq/g, 40  $\mu\text{m}$ )

16 cm<sup>2</sup> active area single cell, Nafion impregnated ELAT electrodes

pH<sub>2</sub> = 3.5 bar a and pO<sub>2</sub> = 4 bar, Cell temperature 90°C, Humidifiers: 100°C



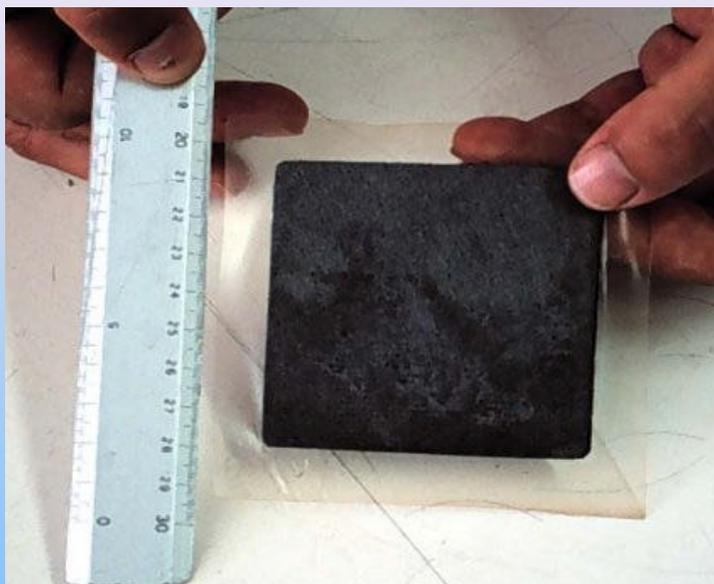
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Membrane electrode assembly  
(CNR-TAE Institute Messina)

PEM fuel cell stack  
(Nuvera Fuel Cells Europe)





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## Users of medium temperature fuel cells

- **mobile applications (prerequisite for mass production)**
  - Passenger cars (2x35 kW stacks)
  - Busses (stacks with a total output of up to 120 kW)
- **stationary applications (advantage in cost reduction)**
  - residential power stations (1 to 30 kW output)
  - Combination of fuel cells and gas turbine emissions
  - On-site energy production (premium power)
  - On-site hydrogen production (water electrolysis)
- **Portable applications (low impact)**