SIXTH FRAMEWORK PROGRAMME

Basic Materials and Industrial Process Research on functional materials for fuel cells

Project acronym: APOLLON-B
Project full title: "Polymer Electrolytes and Non Noble Metal Electrocatalysts for High Temperature PEM Fuel Cells"

Publishable Summary Report

Period Covered: 01.10.2008 to 30.09.2009
Start date of project: 01.10.2006
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Project coordinator name: *Stylianos Neophytides*
Project coordination organisation name: *Foundation of Research and Technology Hellas-Institute of Chemical Engineering & High Temperature Processes*

Publishable executive summary

Hydrogen and fuel cells will open the way to integrated **"open energy systems"** that simultaneously address all of the major **energy** (security, economic competitiveness) and **environmental challenges** (air quality, greenhouse gas reduction), while having the flexibility to adapt to the diverse energy sources that will be available in the Europe of the future. Among the several types of fuel cells, PEM fuel cells have the highest potential for market penetration addressing both stationary and mobile applications.

The most popular PEM fuel cell technology is based on Nafion polymer proton conductor sandwiched between two Gas Diffusion Electrodes, which are mainly based on nanostructured Pt/C supported electrocatalysts. However, the high cost of Nafion and the constrains set because of their low operating temperature (CO poisoning, ineffective exploitation of heat produced) urge towards the design and development of materials (polymer electrolytes and electrocatalysts) which will allow the operation of PEM fuel cells at temperatures ranging within 130°-200°C.

Within the frame of the, **APOLLON-B** project the research was focused on the development of materials for High Temperature PEM Fuel Cells which can be functional within the temperature range of 160-200°C. Their application in High Temperature PEM Fuel Cells will permit their efficient operation under *H_2/H_2 reformate* fuel aiming to power densities of the order of 0.15-0.4W/cm^2 at a cell voltage ranging between 0.7-0.5 V (Fig. 1) and significantly reduced manufacturing cost of the membrane electrodes assembly.

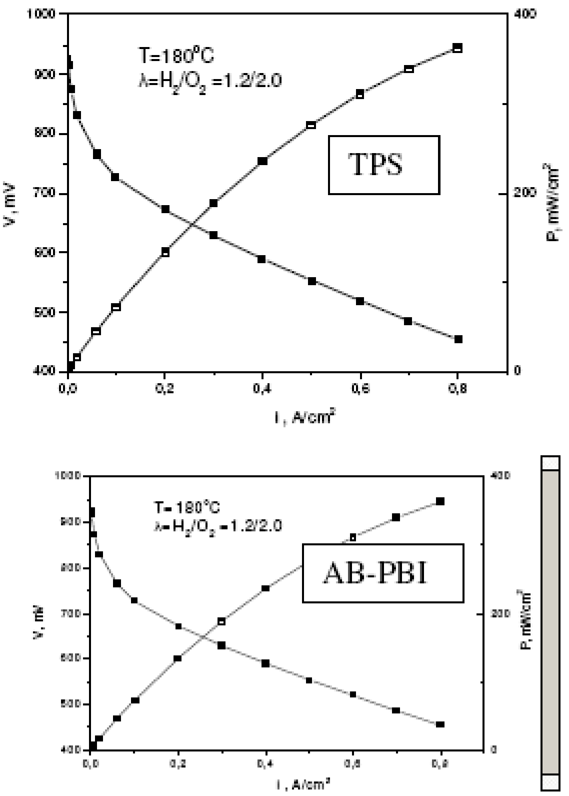
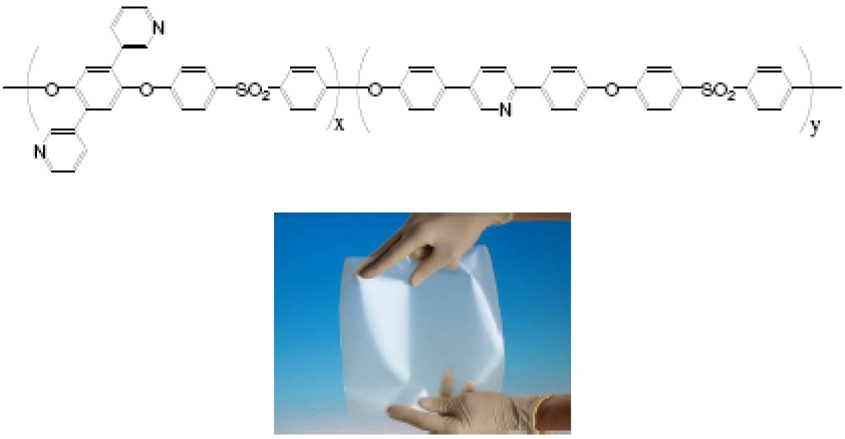


Fig. 1. Current voltage characteristic curves of the MEA based on TPS membrane and AB-PBI

The successful implementation of the project demanded the integration and combination of several methodologies including theoretical calculations and several physicochemical methods, as well as engineering aspects and technical substantiation.

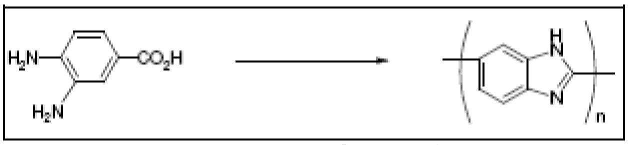
The major achievements of the project can be summarised as follows:

- Synthesis optimization and production of new phosphoric acid polymer membranes based on pyridine units containing aromatic polyethers (TPS Scheem 1)



Scheme 1. TPS chemical structure

and ABPBI based polymers (Scheem 2). These materials can be used as proton conductors at temperatures as high as 200oC.



Scheme 2. AB-PBI chemical structure

- Nanostructured Pt based alloys with Co and Cu which are used as electrocatalysts containing minimal amount of Pt. They can be up to fivefold more active than conventional Pt electrodes
- Manufucture of state of the art MEAs with
- New high temperature carbon composite bipolar plates for high temperature stack assembly that can operate at 200°C.

In addition significant scientific research was conducted on non noble metal electrocatalysts based on FeN/C, on the investigation of new electrolytes based on ionic liquids imbibed polymeric membranes and theoretical modelling so that a better insight and understanding has been achieved regarding the catalytic activity and compatibility of perovskites and FeN containing graphene type C structures for the cathodic oxygen reduction reaction.

The APOLLON-B partnership had **advanced knowledge, techniques and expertise** in the field of High Temperature PEM Fuel Cells that can provide significant progress and innovative solutions in efficient and low-cost PEM Membrane Electrode Assemblies. This consortium drew together the competent resources of **7 member states** (Greece, Netherlands, Germany, Czech Republic, Denmark, Slovenia and Spain). The partnership included **7 research and academic organisations** with advanced knowledge in the synthesis and study of nanosized electrocatalysts, membrane synthesis, theoretical design and synthesis of catalysts, electrode preparation and characterisation and **4 industrialists** (Nedstack, Systems Sunlight, Fumatech and Advent) with the ability to design, produce and test components such as proton conducting membranes, membrane electrode assemblies and fuel cell stacks, for High Temperature PEM Fuel cells based on improved materials.

In this specific context, the APOLLON-B consortium was able to conduct efficient and systematic research in the above mentioned fields throughout the three years of its duration. This, together with the excellent collaboration between the partners, led the consortium to meet the required milestones and the scientific criteria that will enable the commercialization of the technology in the near future. The partners intend to keep the consortium "alive" through the continuation of their research on a new, Apollon C project; this is an outcome of the outstanding scientific achievements of the previous two projects (A & B) as well as the excellent interpersonal relationships that have been formed throughout their collaboration.

The Consortium

- Foundation for Research and Technology HELLAS
- FuMA-Tech Gesellschaft für funktionelle Membranen und Anlagentechnologie GmbH
- Nedstack Fuel Cell Technology BV
- Advanced Energy technologies S.A
- University of Patras
- Vysoka skola chemicko-technologicka v Praze
- Consejo Superior de Investigaciones Cientificas
- Kemijski Institut Ljublana Slovenia
- Danmarks Tekniske Universitet
- Ruprecht Karls Universitat Heidelberg
- Systems Sunlight S.A