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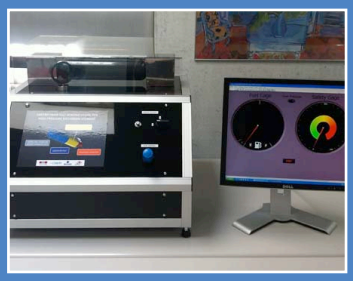
GreenPower

CONNECTING RENEWABLE ENERGY TO GREEN MOBILITY USING HYDROGEN AS ENERGY CARRIER UNDER THE BELENOS CLEAN POWER INITIATIVE



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What it's about…

Demonstrating a Swiss technology for hydrogen mobility with optimization of the overall energy flow and focus on hydrogen storage and use in a fuel cell.

Context and project goals

The use of H_2 based on renewable resources to substitute fossil fuels for mobility and stationary applications is key to reduce CO_2 emissions. The challenges targeted by the project are cost reduction and enhanced safety, primarily for i) H_2 storage under high pressure through the development of polymer composite vessels with unique self-sensing liners and ii) use in fuel cells with novel grafted polymer membranes.

How the project differentiates from similar competition in the field

The polymer membranes for the fuel cell are less expensive and more durable than commercial membranes thanks to a novel radiation grafting chemistry. The polymer composite hydrogen storage vessels include for the first time a self-sensing piezoelectric 'liner' and are produced using a cost-effective fiber weaving technology. The optimization of the energy system includes all process steps (production, storage, use).

Quick summary of the project status and key results

In 2013 *proton-exchange membranes* (PEM) were produced with superior durability compared to commercial PEM. A demonstrator of a *self-sensing composite vessel* for high pressure storage was produced, including a novel liner material with outstanding combination of gas-barrier and piezoelectric properties. The *energy flow optimization* was implemented on the associated user's interface and methods were studied for fuel cell health monitoring. *Belenos car and boat demonstrators* accomplished one year test under real drive and navigation conditions.

Success stories

- L'Agefi "Swatch: projet de véhicule à hydrogen et oxygène" (26.03.2012)
- Tribune de Genève « Swatch n'a pas renoncé à sa voiture propre » (26.03.2012)
- Le Matin « A quand une Belenos à 18 000 francs ? » (26.03.2012)
- 20 Minuti Ticino « La Swatch (ri)pensa a un'auto » (26.03.2012)
- RTS « Swatch veut développer une voiture écologique » (25.03.2012)
- Romandie.com « Swatch envisage de fabriquer une voiture écologique » (25.03.2012)
- Finanzen.ch « Hayek entwickelt das Auto der Zukunft » (25.03.2012)
- Handelszeitung.ch « Hayek entwickelt das Auto der Zukunft » (25.03.2012)
- Search.ch « Swatch envisage une voiture verte » (25.03.2012)
- Touring « La Suisse contribue au futur de l'auto » (19.05.2011)
- Environnement « Mobilté du futur : entre science-fiction et réalité » (01.09.2012)

Proton exchange membranes (PEM). Commercialization of polymer electrolyte fuel cell technology calls for components that yield high performance and durability at low cost. Commercial perfluorinated membranes (e.g., Nafion®) are associated with high production cost. Radiation grafted membranes, such as the one developed at PSI, offers the prospect of reduced cost by a factor of 2 to 5, under ideal conditions by a factor of 10. In the course of the Nano-Tera Greenpower project, the following technological achievements were accomplished:

- Scale-up of membrane fabrication in the lab to a batch size equivalent to a fuel cell stack of 3.5 kW
- Fuel cell performance equivalent to commercial benchmark
- Durability exceeding that of state-of-the art membranes under dynamic operating conditions.

Piezoelectric gas barrier liner. The collaboration between EPFL and CSEM on the analysis of a P(VDF-TrFE) copolymer was instrumental to elucidate the transformation of the paraelectric crystalline phase into the polar β-phase upon annealing between the Curie temperature and the melting point. This thermal process enhanced the proportion of β-phase up to 95%, leading to a remarkable 10-fold decrease of O_2 permeability and 40% increase in the piezoelectric coefficient d33.

Main publications

H. Ben youcef, S. AlkanGürsel, A. Buisson, L. Gubler, A. Wokaun, G. G. Scherer, Influence of Radiation-Induced Grafting Process on Mechanical Properties of ETFE-Based Membranes for Fuel Cells, Fuel Cells, 10 401-410 (2010)

L. Gubler , G. G. Scherer, Trends for fuel cell membrane development, Desalination 250, 1034–1037 (2010)

S. Balog, U. Gasser, K. Mortenssen, H. Ben youcef, L. Gubler, G. G. Scherer, Nano-scale morphology in graft copolymer proton-exchange membranes cross-linked with DIPB, J. Membrane Sci. 383, 50-59 (2011)

H. Ben youcef, L. Gubler, A. Foelske-Schmitz, G.G. Scherer, Improvement of homogeneity and interfacial properties of radiation grafted membranes for fuel cells using diisopropenylbenzene crosslinker, J. Membr. Sci. 381, 102– 109 (2011).

S. Balog, U. Gasser, K. Mortenssen, H. Ben youcef, L. Gubler, G. G. Scherer, Structure of the ion-rich phase in DVB cross-linked graft-copolymer proton-exchange membranes, Polymer 53, 175-182 (2012)

F. Wallasch, M. Abele, L. Gubler, A. Wokaun, K. Müller, G.G. Scherer, Characterization of radiation grafted polymer films using CP/MAS NMR spectroscopy and confocal raman microscopy, J. Appl. Polym. Sci., 125, 3500-3508 (2012).

S. Dalle Vacche, F. Oliveira, Y. Leterrier, V. Michaud, D. Damjanovic, J.-A.E. Månson, The effect of processing conditions on the morphology, thermomechanical, dielectric and piezoelectric properties of P(VDF-TrFE)/BaTiO3 composites, J. Mater. Sci., 47, 4763-4774 (2012).

Leterrier Y., Thivolle J., Oliveira F., Månson J.-A.E., Gubler L., Ben youcef H., Bonorand L.,, Viscoelastic Phase Diagram of Fluorinated and Grafted Polymer Films and Proton Exchange Membranes for Fuel Cell Applications, J. Polym. Sci. B: Polym. Phys., 51, 1139-1148 (2013)