Summary

Topical Meeting of the IEA AFC TCP on

Potential for cost reduction and performance improvement for PEMFC at component and system level

Viktor Hacker & D.J. Liu

10/11 November 2021, TU Graz

USA -7 (Chicago)	Asia +8 (Seoul)		
			Wednesday, 10. November 2021 – Afternoon session
09:00	00:00	16:00	**Welcome** Detlef Stolten (FZ Jülich), Di-Jia Liu (ANL), Viktor Hacker (TU Graz)
09:40	00:40	16:40	**Recent advances of PEMFC technologies and challenges for applications beyond personal owned vehicles** Hongfei Jia (Toyota North America)
10:10	01:10	17:10	**Engineering Solutions for Economical and Durable Fuel Cell Vehicles** Erik Kjeang (Simon Fraser University, Canada)
10:40	01:40	17:40	**Cost-efficient and environmentally friendly recycling of materials in PEM fuel cells and electrolysis cells** Mikkel Juul Larsen (IRD, Denmark)
11:10	02:10	18:10	**PEMFC Development for Road and Maritime Applications** Richard Schauperl (AVL, Austria)
11:40	02:40	18:40	**Closing**
			Thursday, 11. November 2021 – Morning session
02:00	17:00	09:00	**Welcome**
02:10	17:10	09:10	**High Pressure Nitrogen-infused ultrastable Core-Shell Catalyst for the Oxygen Reduction Reaction of Fuel Cells** Gu-Gon Park (KIER, Korea)
02:40	17:40	09:40	**Hybrid PEM fuel cell systems** Sönke Gößling (ZBT, Germany)
03:10	18:10	10:10	**Fuel Cell research in Spain with a focus on potential for cost reduction and performance improvement for PEMFC at component and system level** Alfredo Iranzo (University of Sevilla, Spain)
03:40	18:40	10:40	**Membrane Electrolyte Assembly for Polymer electrolyte fuel cell** Hongmei Yu (Dalian Institute of Chemical Physics, China)
04:10	19:10	11:10	**Closing**
			Thursday, 11. November 2021 – Afternoon session
09:00	00:00	16:00	**Welcome**
09:10	00:10	16:10	**PBI-based High Temperature PEMFC – from materials to systems** Hans Aage Hjuler (Blue World, Denmark)
09:40	00:40	16:40	**Aquivion®-based MEA for enhanced PEFC performance** Alessandra Carbone (ITAE CNR, Italy)
10:10	01:10	17:10	**Application of stationary fuel cells for the local energy transition** Philipp Rechberger (Fronius, Austria)
10:40	01:40	17:40	**Discussion**
11:10	02:10	18:10	**Closing**

CONTENTS

INTRODUCTION

On 10/11 November 2021, the Topical Meeting on *Potential for cost reduction and performance improvement for PEMFC at component and system level* took place at Graz University of Technology. Due to the prevailing Corona situation at the time, the event was geared largely towards online participation, but (additional) personal attendance was also possible. A video stream of the event and interactive discussion of questions, both via chat and directly, allowed for a lively meeting in the auditorium of Graz University of Technology and online.

Internationally recognised experts from research and development as well as from industry gave interesting presentations discussing various aspects and developments on this topic. The main topics included fuel cell research, fuel cells for mobile applications, production and manufacturing processes as well as the recycling of fuel cell components (catalyst, MEA, etc.).

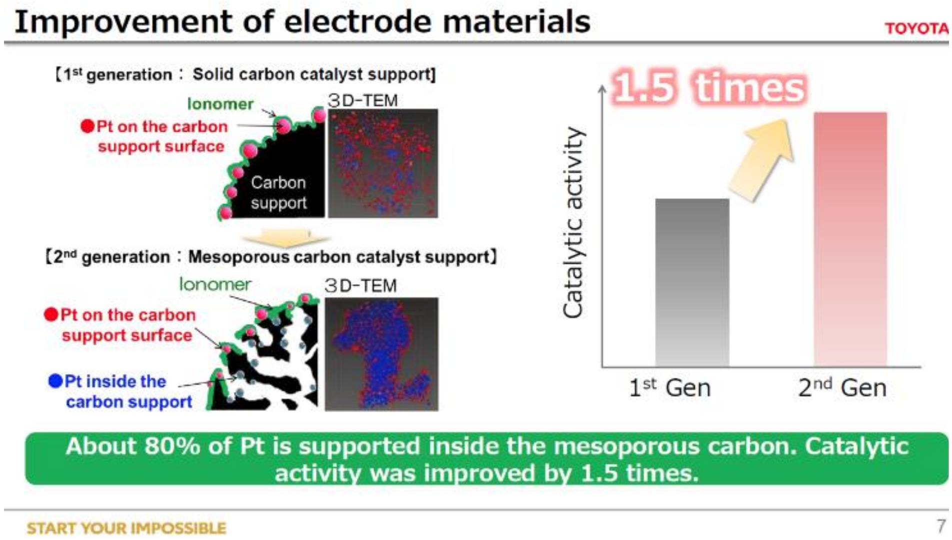
The topics of the presentations were:

- Recent advances of PEMFC technologies and challenges for applications beyond personal owned vehicles
- Engineering Solutions for Economical and Durable Fuel Cell Vehicles
- Cost-efficient and environmentally friendly recycling of materials in PEM fuel cells and electrolysis cells
- PEMFC Development for road and maritime applications
- High Pressure Nitrogen-infused ultrastable Core-Shell Catalyst for the Oxygen Reduction Reaction of Fuel Cells
- Hybrid PEM fuel cell systems
- Fuel Cell research in Spain with a focus on potential for cost reduction and performance improvement for PEMFC at component and system level
- Membrane Electrolyte Assembly for Polymer electrolyte fuel cell
- PBI-based High Temperature PEMFC – from materials to systems
- Aquivion based MEA for enhanced PEFC performance
- Application of stationary fuel cells for the local energy transition

PRESENTATIONS

Recent advances of PEMFC technologies and challenges for applications beyond personal owned vehicles

Hongei Jia (Toyota, North America)

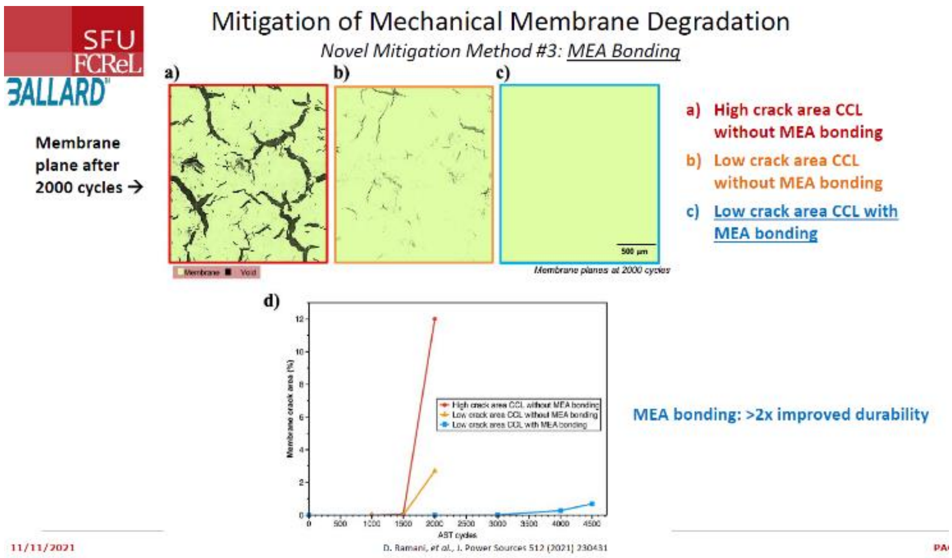


The presentation showed the evolution from the first generation Mirai to the second generation and the extent of the improvements based on various parameters. The advances led to an increase in maximum power and also to a longer operating time.

The electrode material and ionomer were changed/improved (mesoporous carbon carrier), which enabled an increase in performance. In addition, the flow channel was also changed (narrowed channel tips).
High-speed production of a few seconds per cell was achieved by increasing the coating speed, changing the coating orientation, using new sealing material and reducing the assembly time of the cells.
Currently, the focus is on private vehicles, but future plans include expansion to applications beyond POVs, e.g. trucks, buses, aircraft, etc.

Engineering Solutions for Economical and Durable Fuel Cell Vehicles

Erik Kjang (Simon Fraser University, Canada)



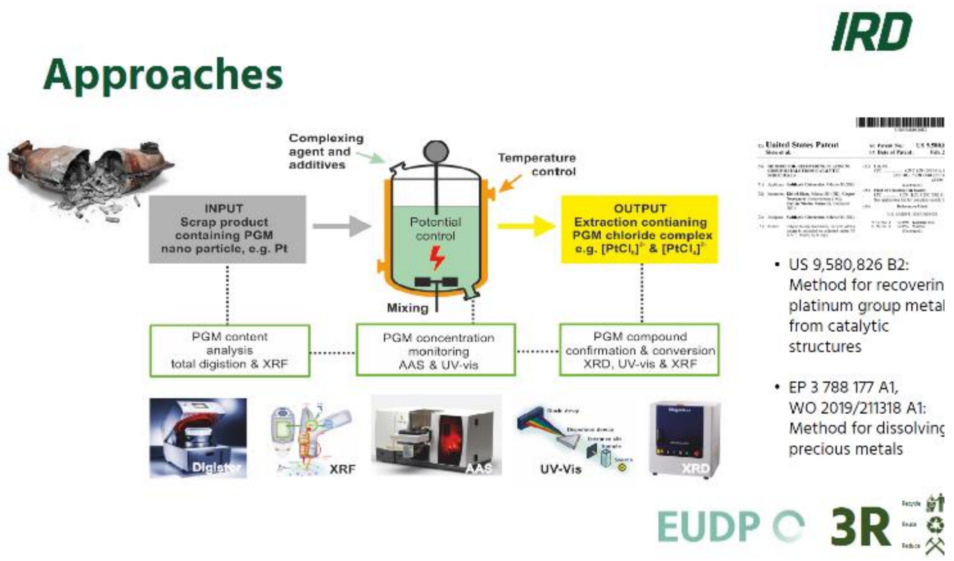
The first part of the presentation deals with CO impurities in hydrogen and shows different solutions to mitigate these problems. Possibilities were presented that are achieved by using more CO tolerant catalyst materials in combination with an air bleed measurement method and/or a pulsed oxidation measurement method.

In the air bleed method, the air/oxygen reacts catalytically with the carbon monoxide (covers the catalyst) at the anode catalyst. CO_2 is formed, which only interacts weakly with the catalyst and can be easily desorbed. This again creates free sites for H_2 electrooxidation. High power recovery is possible with air bleed and/or pulsed oxidation.

The second part of the presentation dealt with improving the durability of fuel cell membranes. Advances were achieved by using catalyst layers with low crack density (delays mechanical membrane failure), GDLs with low surface roughness (LSR; reduces CCM buckling) and specific MEA bonding (CCM & GDLs hot-pressed; prevents CCM buckling).

Cost-efficient and environmentally friendly recycling of materials in PEM fuel cells and electrolysis cells

Mikkel Juul Larsen (IRD, Denmark)



The Danish companies IRD Fuel Cells A/S and CriMaRec ApS, together with the University of Southern Denmark, are developing efficient and sustainable processes for recycling platinum group metals (PGMs), mainly platinum and iridium, with the aim of creating production alternatives to the costly, energy-intensive and environmentally harmful conventional processes.

In this presentation, ways to minimise costs through recycling were highlighted. The concept is to reuse the MEAs through a special recycling process that includes delamination, dissolution, purification and reuse of PFSA for the membrane and concentration, synthesis and drying for the catalyst.The main objectives of recycling are to reduce dependence on the primary PGM feedstock and to reduce MEA costs.

PEMFC Development for road and maritime applications

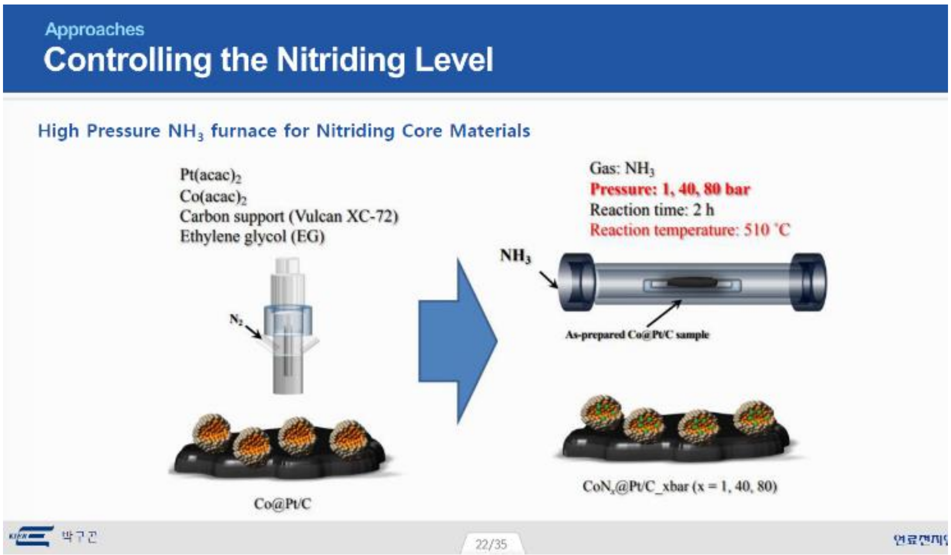
Richard Schauperl (AVL, Austria)

AVL presented the company's developments in fuel cell advancements for automotive and marine applications. Possible improvements for the bipolar plates were presented, which include optimisation in the following areas: minimising the pressure differences between the fluids to reduce the mechanical load, extending the service life, geometry optimisation (flow performance, strength), etc.

In addition, the previous model (Gen0) of the fuel cell stack was compared to the new model (Gen1) and the improvements were discussed (higher power density, lower platinum loading, longer lifetime, etc.). This stack can be used for: Range extender (≈35 kW), Automotive (≈100 kW), HD-Truck (≈300 kW), Marine (≈1,3 MW) and various other applications.

High Pressure Nitrogen-infused ultrastable Core-Shell Catalyst for the Oxygen Reduction Reaction of Fuel Cells

Gu-Gon Park (KIER, Korea)

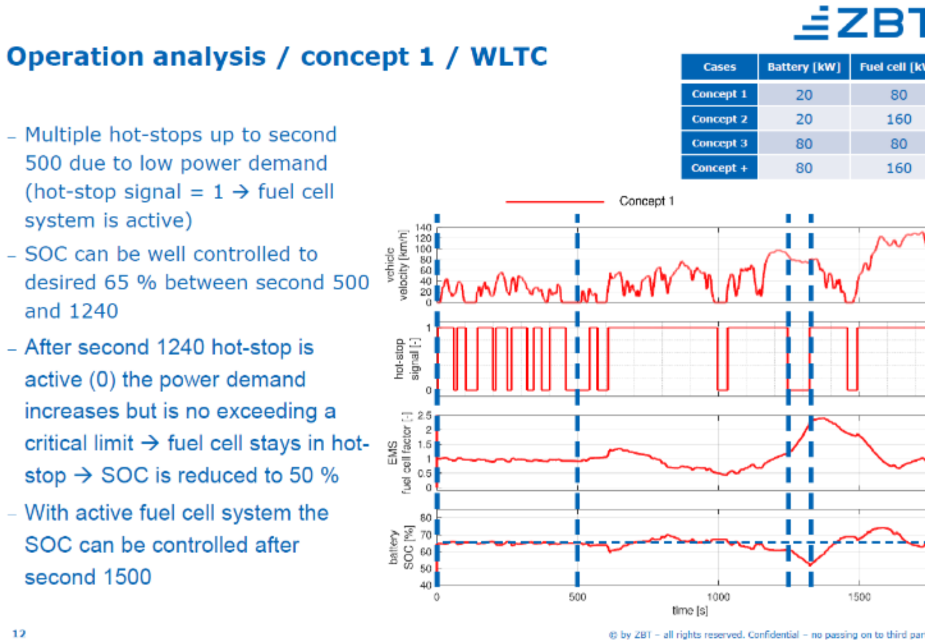


The application/development of new catalysts was presented here. The research focuses mainly on the use of core-shell catalysts for the oxygen reduction reaction. Base metals/transition metals are used as core materials, which are nitrided, with platinum providing the outer skin of the catalyst. The nitriding level can be determined by changing the ammonia pressure during thermal treatment.

The high pressure nitrogen-infused PtCo/C catalyst exhibited a two-fold increase in mass activity and a five-fold increase in durability compared with commercial Pt/C, exhibiting retention of 80% of the initial mass activity after 180k and maintaining the core-shell structure even after 1000k cycles of accelerated stress tests. The best performance was observed for PtCo with N_2.

Hybrid PEM fuel cell systems

Sönke Gößling (ZBT, Germany)

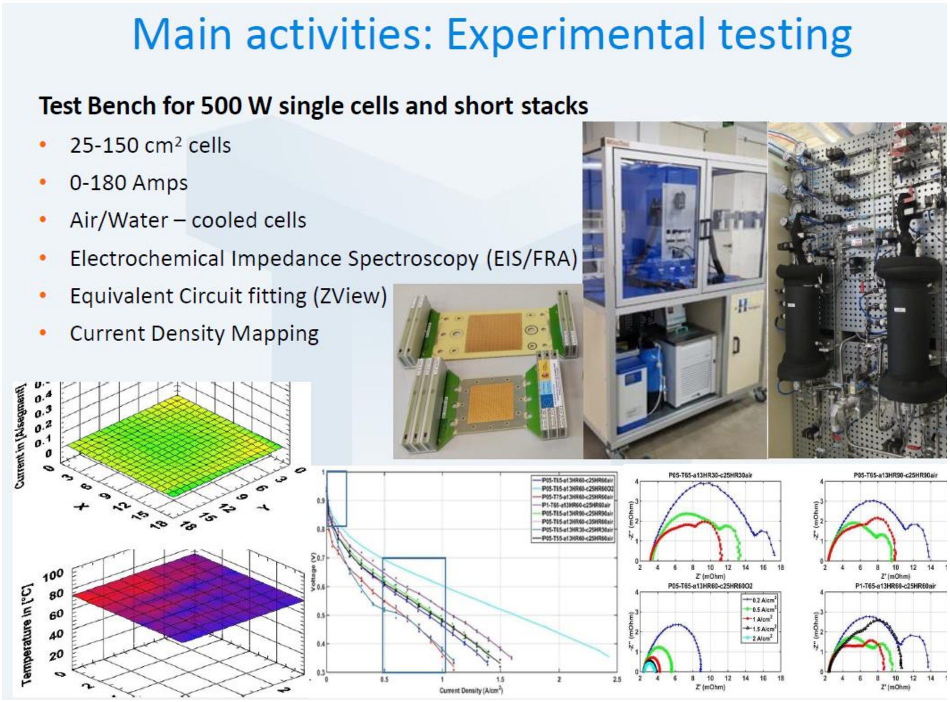


Nowadays, PEM fuel cell systems for passenger cars are realized as hybrid systems. If the architecture of a hybrid system is given, then the dimensioning of the fuel cell and battery subsystems is crucial in terms of costs, dynamics, and driving behavior in general. In order to analyze these dependencies correctly, the ZBT fuel cell model was integrated into a fuel cell system and a full vehicle simulation.

Several operating concepts for a fuel cell hybrid vehicle were presented, whereby the maximum power of the battery or fuel cell was varied. Requirements for operation was to keep the SOC of the battery in an average range of 65% (protection of the battery from overload) and a hot-stop strategy was developed to avoid inefficient and harmful operation at very low loads. The comparison of the four concepts, neglecting cost aspects, shows that a medium-size fuel cell system and a medium-size battery prove to be advantageous.

Fuel Cell research in Spain with a focus on potential for cost reduction and performance improvement for PEMFC at component and system level

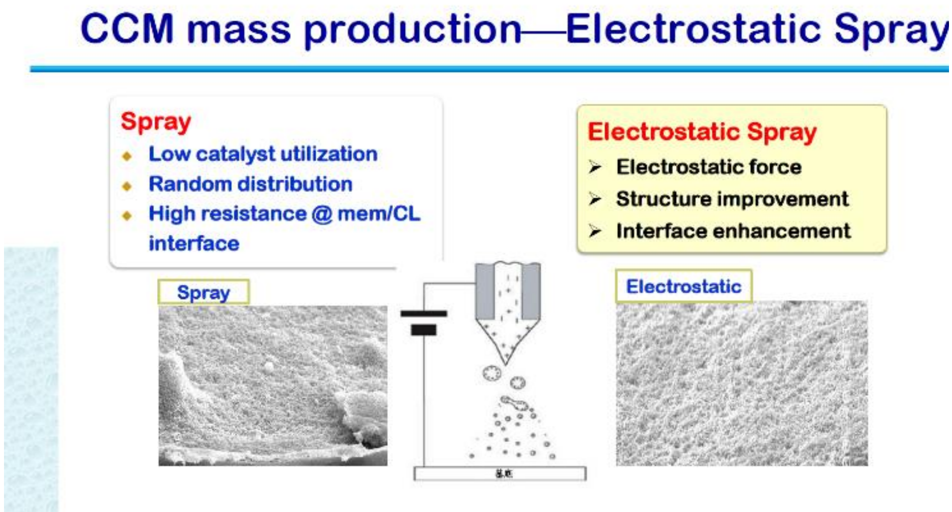
Alfredo Iranzo (University of Sevilla, Spain)



The main activities in PEM fuel cell R&D in Spain were presented. These were divided into the areas of universities, research and technology centres and industry. In the universities, the focus of FC research is on the further development of individual fuel cell components (e.g. Pt loading, durability, BPP and membranes). The main research areas at the R&T centres are the integration of PEMFC systems, BPP and mechanical design optimisation. In Spain, industry focuses mainly on UPS power systems, m-CHP, Cells, Stacks, BPP research and Focused on system development and system integration. In relation to the topic of this meeting, the University of Seville has its main focus on the CFD application, Water management analyses, BPP design, system integration etc.

Membrane Electrolyte Assembly for Polymer electrolyte fuel cell

Hongmei Yu (Dalian Institute of Chemical Physics, China)



In this presentation, ways to reduce the cost of the MEA are presented. In particular, the precious metal loading is reduced, as this is the main cause of the high PEMFC costs. Different catalyst types and different components are examined. Among other things, an electrostatic spray method was used, which allows for the mass production of CCMs.

The focus is on the development of 1) non-Pt metal catalysts and 2) the use of other metals (Pd, Fe, Co, Ni and Cu) with Pt to form a core-shell structure or various alloys. Catalyst layers with nanostructure, i.e. Pt/Nb_2O_5 nanobelt, PtCo nanotube array and Pt-Ni nanobelt were prepared and tested in PEMFC single cells. Experiments were conducted at low platinum loading, low humidity and ambient air and it was found that the performance of fuel cells with nanostructure catalyst layers are comparable to conventionally composed CCMs.

PBI-based High Temperature PEMFC – from materials to systems

Hans Aage Hjuler (Blue World, Denmark)

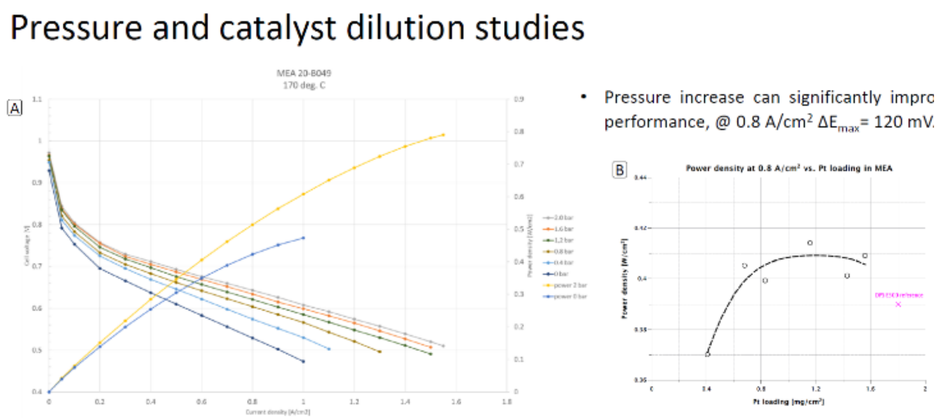


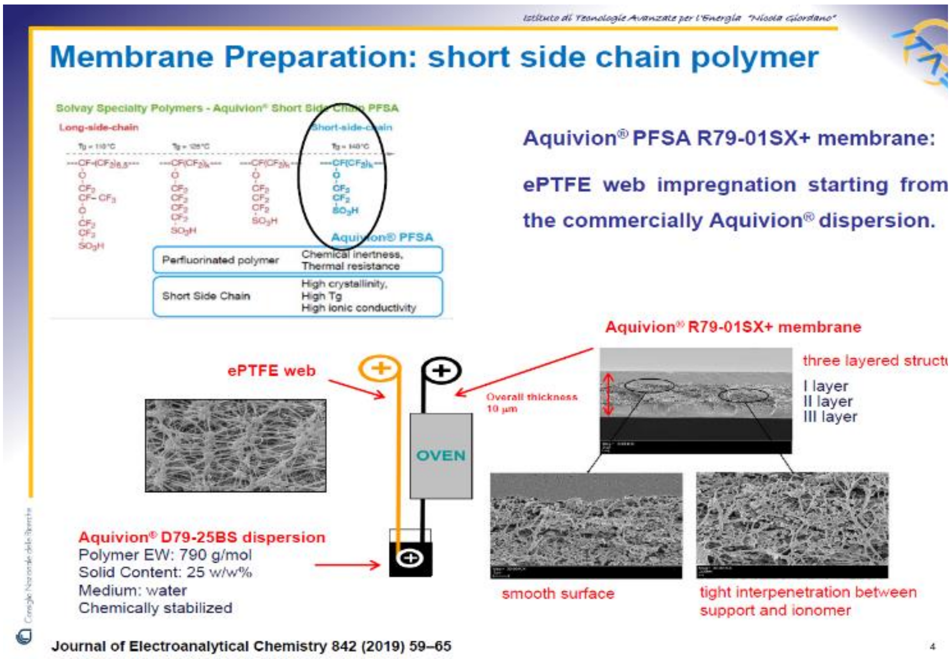
Figure 4. (A) Polarization curves at different cell overpressures. (B) Power level at 0.8 A/cm^2 and cell Pt utilization. Tested at operating conditions: $\lambda_{Ref.}/\lambda_{Air}$= 1.3/2.5 ,T=160 °C, active area = 21 cm^2, i = 0.9 A/cm^2. Reformate = 1.4% CO, 22.3 % CO_2, 69.3% H_2, 6.9% H_2O.

Blue World Technologies is a developer and manufacturer of methanol fuel cell components and systems for the automotive and heavy-duty transport sectors, as well as for stationary and APU applications. They also focus on the development of materials for flow batteries and electrolysis systems. Danish Power Systems and Blue World were merged in January 2021, with DPS specialising in the production and development of HT-PEM fuel cells.

This presentation will focus on the development and research of the HT-PEM fuel cell, which is operated with a (special) PBI (Polybenzimidazole) membrane (Dapozol). No gas purification is needed here, which makes the HT-PEM easier to use and cost-efficient. Tests were carried out with various reformate compositions, including long-term tests and start-stop tests. In these tests, various catalysts (platinum and alloy catalysts) as well as diverse pressure applications were tried out. A long durability (more than 12 000 hours) and an increase in power density (at 1.5 bar, 170 °C, 0.8 A/cm^2) could be achieved. Large scale manufacturing of these systems is in progress.

Aquivion based MEA for enhanced PEFC performance

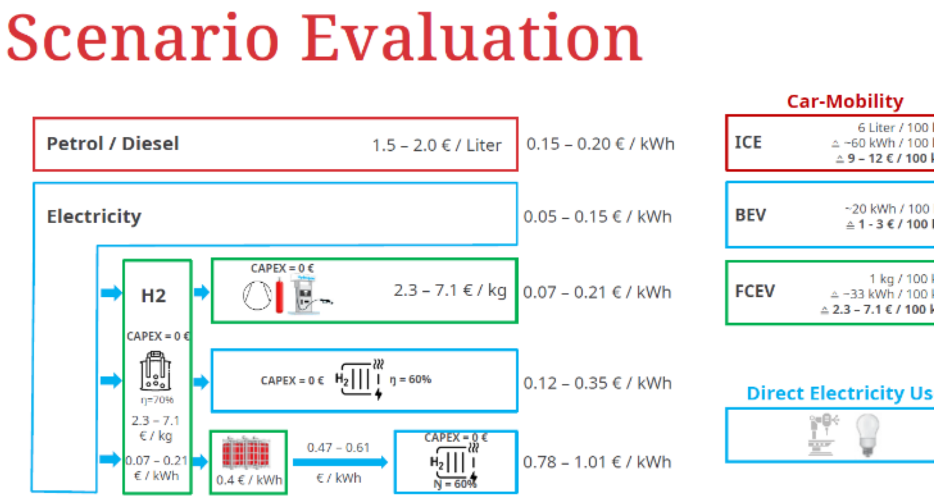
Alessandra Carbone (ITAE CNR, Italy)



Nafion is one of the most frequently used PFSA ionomers for the catalyst layer of MEA. It is based on long-chain PFSA ionomers (LSC-PFSA) with a higher equivalent weight (EW 1100). At a working temperature above 90 °C or relatively low humidity, its proton conductivity rapidly decreases. Aquivion is an alternative PFSA polymer that is a short-chain PFSA ionomer (SSC-PFSA, EW 790). The shorter side chain (and the absence of the pendant -CF_3 group) favours a higher fuel cell operating temperature. Various MEAs with different catalysts, e.g. Pt/C and PtCo/KB, were analysed using accelerated stress tests. The results show that MEAs based on PtCo/KB cathode catalysts (subjected to accelerated stress tests) compared with the Pt/C catalyst, resulting in superior performance. Also an improvement of the MEA stability could be achieved by changing the properties of the ionomer. And the catalytic layer with a high EW (830 meq/mol) showed higher degradation than the ionomer with a lower EW (790 meq/mol) during the accelerated stress test at OCV.

Application of stationary fuel cells for the local energy transition

Philipp Rechberger (Fronius, Austria)



Fronius is a manufacturer of electrolysis systems, supplier of renewable energy solutions and system integrator. The presentation provides an overview of current research and development projects, such as a project currently underway to develop a fuel cell system based on a stack that is already commercially available.

Projects are being carried out with the aim of advancing the industrialisation of PEM electrolysis stacks and systems as well as fuel cell systems, improve electrolysis stack design with new catalysts and new manufacturing processes for bipolar plates, develop stationary fuel cell systems in the power range from 10 to 50 kW etc. In the presentation an insight in application scenarios of small-scale stationary hydrogen systems was given. Also, the interaction and dependency of batteries and fuel cells was in the focus of this talk.

IMPRESSIONS


Advanced Fuel Cells
TU


IEA Technology Collaboration Programme
Advanced Fuel Cells
TU
Graz
Welcome!


Test equipment in Kvistgård

Summary

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IEA AFC TCP for PEMFC at component and system level

10./11. November 2021

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