Improved Lifetime of Automotive Application Fuel Cells with Ultra-Low Pt-Loading

IMPACT
(303452)

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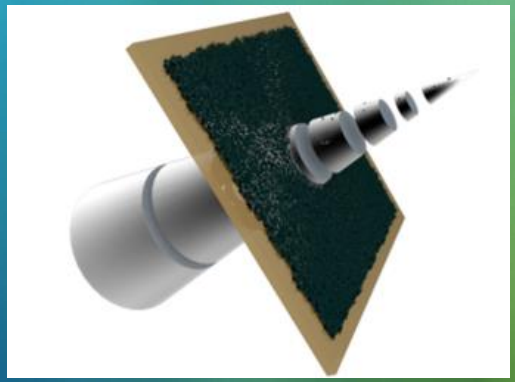


PROJECT OVERVIEW

- Call topics:
  - SP1-JTI-FCH.2011.1.6 Investigation of degradation phenomena
  - SP1-JTI-FCH.2011.1.5 Next generation European MEAs for transportation applications
- Application Area: Automotive
- Duration: 01.11.2012 – 31.10.2016 (75% project duration passed)
- Budget:
  - 9,144,435€ total budget
  - 3,902,403€ FCH JU contribution
- Summary of the Project:
  - understanding of degradation mechanisms, the improvement of lifetime of fuel cells with ultra-low noble metal loading
  - development of MEAs with ultra-low noble metal loadings. The MEA development occurs iteratively and is tested in single cells and stacks in constant current and dynamic load cycling conditions.

PROJECT TARGETS AND ACHIEVEMENTS

Programme objective/target	Project objective/target	Project achievements to-date	Expected final achievement
1. MAIP			
Demonstration of long-term stability under automotive fuel cell conditions	lifetime of 5,000 h in dynamic operation, with a degradation rate below 10 μVh^{-1}	>1000 h test shows irreversible decay rates of **10 - 65 μVh^{-1}** at 1A/cm^2	irreversible decay rate of <10 μVh^{-1} in a >2,500 h cycling test
2. AIP			
Irreversible and reversible degradation mechanism categorization	Improving the understanding of reversible and irreversible loss and the nature of degradation associated to these losses	Methods to determine irreversible degradation rate and procedures for performance recovery analyzed	Better understanding of recovery of reversible voltage losses

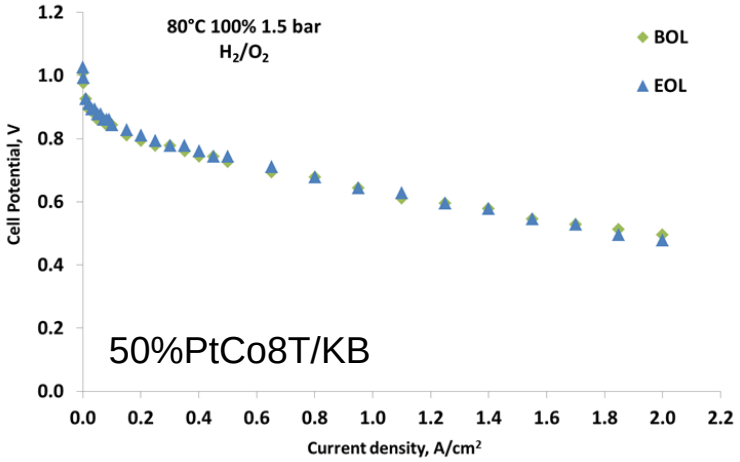
PROJECT TARGETS AND ACHIEVEMENTS

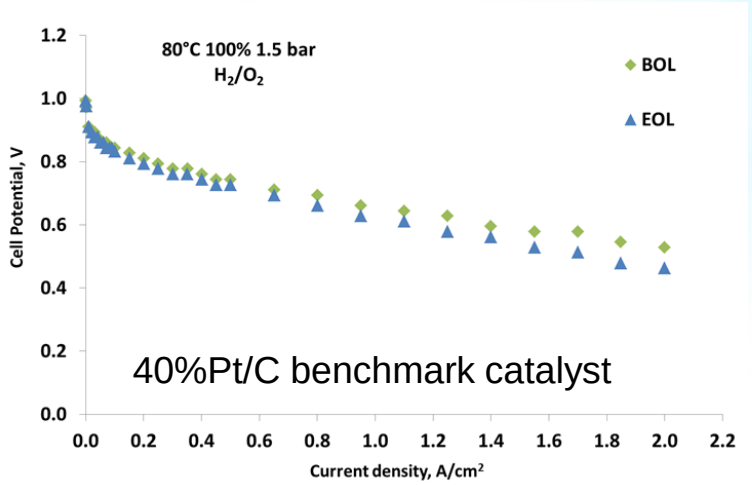
Programme objective/target	Project objective/target	Project achievements to-date	Expected final achievement
3. AIP			
Development of cats and CLs allowing for significant reduction in precious metal loadings	Pt loadings < 0.2 mg_{Pt}/cm^2	Overall Pt loading of 0.25 mg_{Pt}/cm^2 (total)	Overall Pt loading of 0.20 mg_{Pt}/cm^2 (total)
4. AIP			
Development of durable ultra-low loaded MEAs for automotive applications	1 W/cm^2 at 670mV (1.5 A/cm^2) single cell performances 1.5 bar 1.5/2 stoich.	**0.57W/cm²** at 1.5A/cm^2 and 0.25mg_{Pt}/cm^2; **0.82 W/cm²** at 1.5A/cm^2 and 0.4mg_{Pt}/cm^2	1W/cm^2 at 1.5A/cm^2, 0.20mg_{Pt}/cm^2 and increased stoich. or pressure

PROJECT TARGETS AND ACHIEVEMENTS

Cathode Catalysts Development

- PtCo8T/KB preparation; good dispersion of PtCo on carbon; crystallites of 3.3nm
- XRD data confirm the high degree of alloying with ordered alloy structure and XPS shows some segregation of Pt on the surface



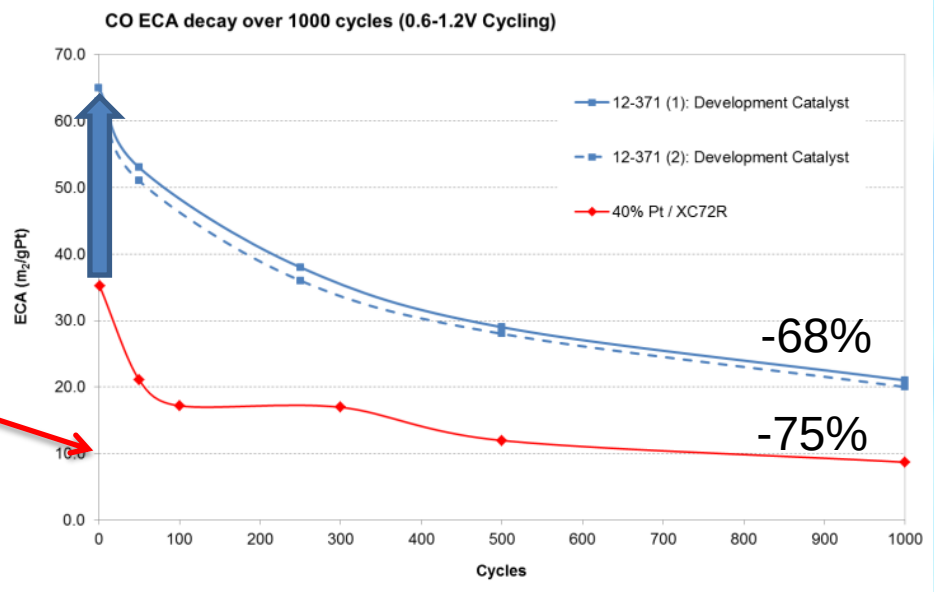


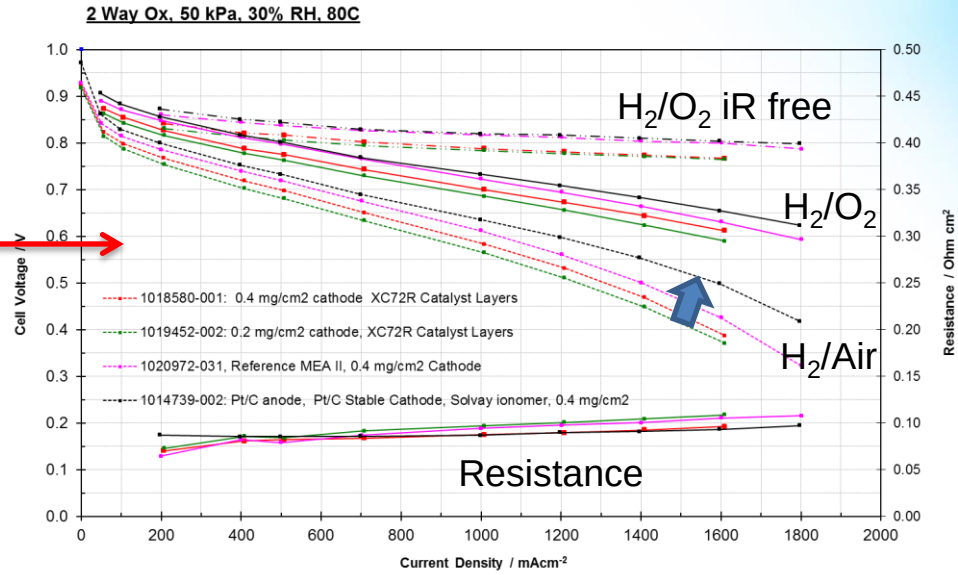
Accelerated stress tests of 50%PtCo8T/KB cathode (0.2 mg Pt cm^{-2}) has shown better stability than the benchmark catalyst. No ECSA changed after 10^4 cycles (0.6-0.9V)

PROJECT TARGETS AND ACHIEVEMENTS

MEA Preparation: Introduction of more corrosion resistant carbon

- Introduction of a more stable carbon support material on the cathode (highly graphitised carbon)
- Greatly increased ECA and resistance to potential cycling losses shows durability benefit.
- Using more stable carbon with Solvay Aquivion® ionomer gave high performance, increased when compared to all baseline MEAs

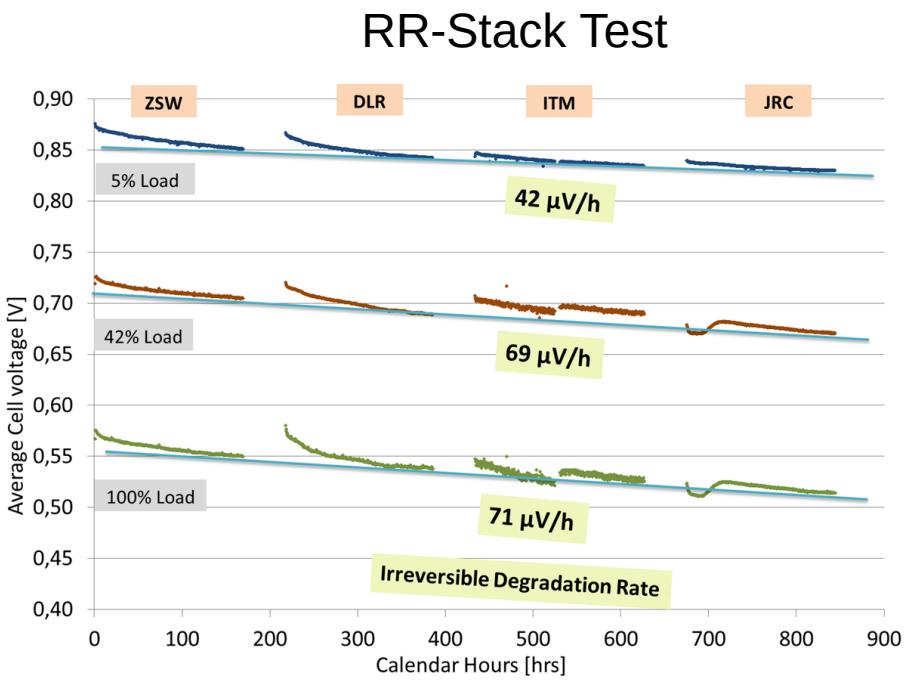




PROJECT TARGETS AND ACHIEVEMENTS

Further achievements:

- Successful scaling up of Pt/KB and PtCo/KB catalyst synthesis
- Successful RR stack test by 4 labs
- >2500 h stack testing using FC-DLC protocol
- Effort in analysis of methods to determine degradation rates



PROJECT TARGETS AND ACHIEVEMENTS

Perspectives:

- Target durability (<10 µV/h) will be probably reached in 2016

What are the next steps?

- Development of improved materials; e.g. new stabilizing agents for PFSA, optimization of ionomer content in CL
- Identification of best material combinations
- Selection of MEA for final durability and performance stack tests
- Demonstration of target MEA durability

RISKS AND MITIGATION

- 1. Lifetime of 5,000 hours in dynamic operation, with a degradation rate below 10 µV/h
  - MEA failing voltage decay target due to ionomer instability in the catalyst layers.
  - Collaborative work between JMFC and Solvay to mitigate against this risk.
  - Probability to reach target estimated to be 70%

- 2. Development of cats and CLs allowing for significant reduction in precious metal loadings
  - Low loading MEA should be suitable to also reach 1 W/cm^2 (see Risk 3)

- 3. Power density of 1 W/cm^2 at 670mV (1.5 A/cm^2) single cell performances
  - Risk connected to risk 2 (above)

➔ Targets will not be revised

Probability to reach both targets ~50%

SYNERGIES WITH OTHER PROJECTS AND INITIATIVES

FCH and FP projects	Interaction and/or joint activities
DECODE	Provides knowledge on degradation Use of DECODE GDLs in IMPACT
Autobrane	Outcomes are also used in IMPACT
Autostack	Provides cost analysis and power targets
Autostack CORE	Uses IMPACT results on ultra-low loaded MEAs under automotive conditions
PremiumAct	Provides results on degradation
Second Act	Provides results on degradation
IMPALA	Exchange about improved GDLs
Stack-Test	Provides test protocols
PEMICAN	Provides input related to low loaded MEAs
NanoCAT	Provides input related to catalyst research
The collaboration with the EU automotive harmonisation activities	

HORIZONTAL ACTIVITIES

- Training and education:
  - A PhD student is working in the project
- Safety, regulations, codes, standards:
  - Contribution to harmonization activities (test protocols for automotive applications)
  - Support of 3rd Degradation Workshop of JRC (Santorini)
- General public awareness:
  - Press release: *EU-Projekt geht neue Wege in der Materialentwicklung für die Brennstoffzelle zum Einsatz in Autos* (UAES)

DISSEMINATION ACTIVITIES

- Contributions to 25 international conferences

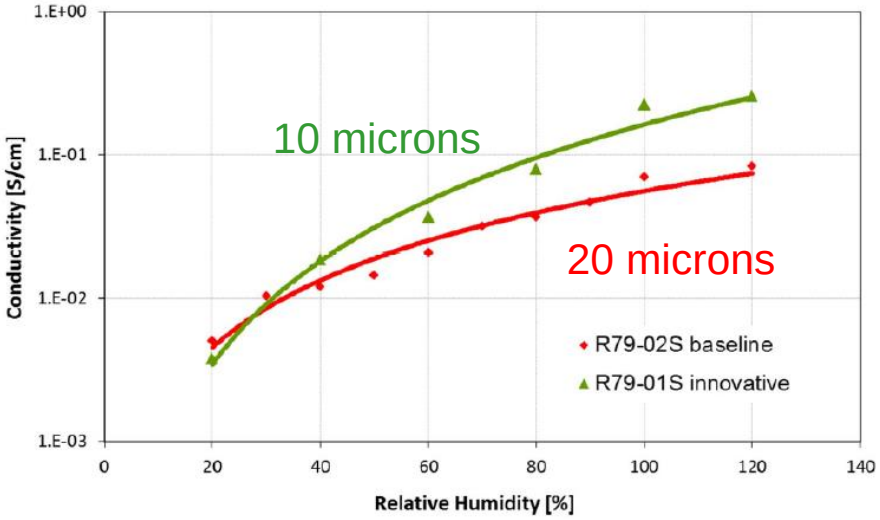
- Organized workshops: Common IMPACT and IMPALA workshop in Toulouse (02.2015)
- 8 Publications (Energies, Electrochim. Acta, J. Electrochem. Soc., ChemSusChem, ECS Trans.)

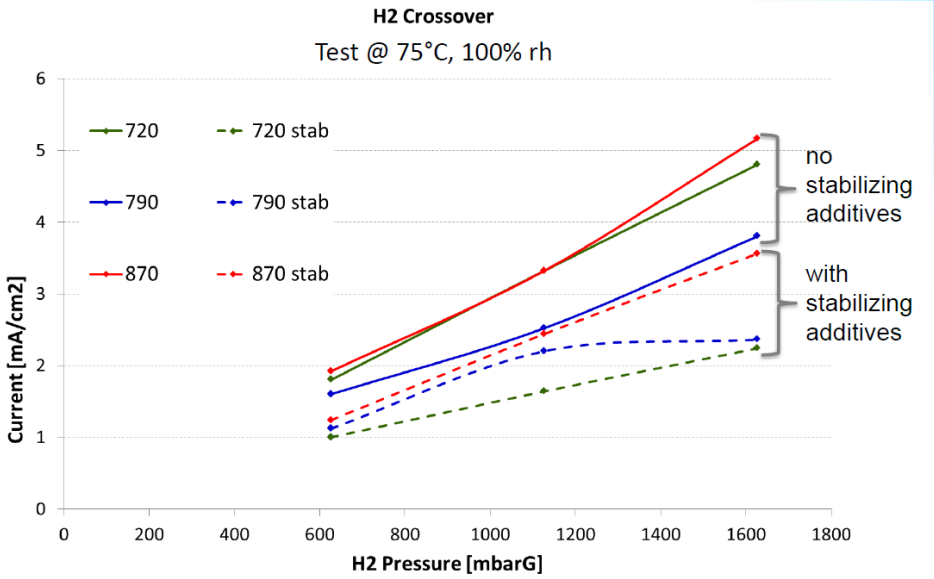
EXPLOITATION PLAN/EXPECTED IMPACT

- How will the project's results be exploited?
  - **Solvay:** membranes and dispersions validated by the project results for the relevant application, can be made available to the market.
  - **JMFC:** MEA developer and manufacturer. The project is providing increased confidence on the enhanced MEA durability of new catalyst components and additives to mitigate against losses caused by support corrosion and cell reversal. These will be incorporated into future MEA products for automotive applications.

EXPLOITATION PLAN/EXPECTED IMPACT

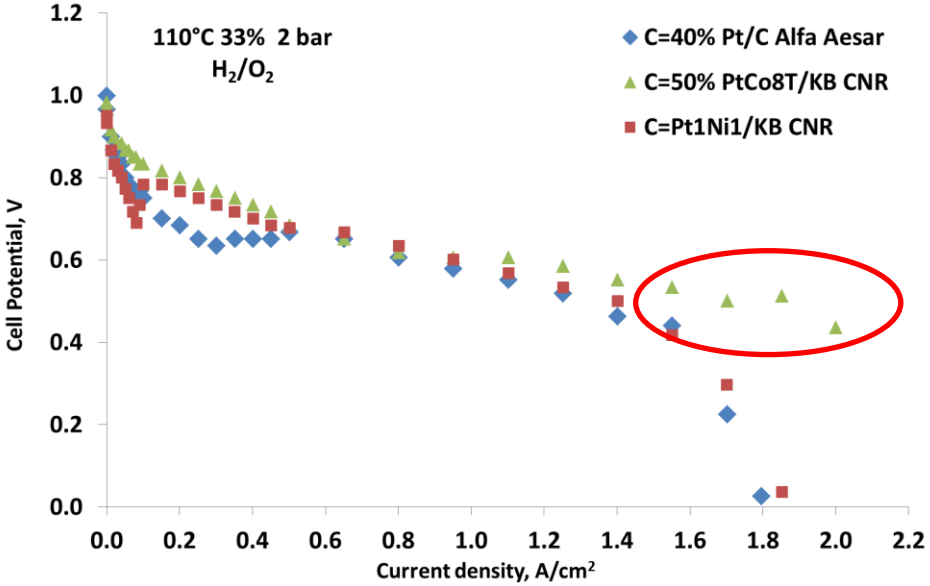
- Selected results going beyond SoA:
  - Reduction of membrane conductivity by development of thinner membranes
  - Reduction of H2 crossover of membranes by introducing stabilizing agents





EXPLOITATION PLAN/EXPECTED IMPACT

- Selected results going beyond SoA:
  - Development of catalyst for high T
  - Development of PtCo/KB cats with superior mass activity



T = 80 C

SAMPLE	Tafel Slope mV/dec	j_m@0.9V_{IRfree} mA/mg
40%Pt/C	64	307
PtCo8T/KB	72	457
Pt_1Ni_1/KB	69	357

Acknowledgements

Thank you for your attention!

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