Improved Durability and Cost-effective Components for New Generation Solid Polymer Electrolyte Direct Methanol Fuel Cells

Collaborative Project - *FCH JU GRANT AGREEMENT N° 278054*

SP1-JTI-FCH.2010.4.4 Components with advanced durability for Direct Methanol Fuel Cells

***Start date**: 01.12.2011 – **Duration**: 36 months*

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DELIVERABLE REPORT

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ABSTRACT	
Keywords	*Dissemination, DMFCs*
Abstract	This deliverable provides a plan for further dissemination and for the use of knowledge and results after the end of the project. For the various workpackages, a list of publications that have been planned for the next months is reported. Duramet project web site update and maintenance are discussed. A new brochure including the final project results and prototypes developed in Duramet is planned. The impact of the activities carried out in the project is elucidated. Exploitation of the project results and future cooperation are also discussed.

CONTENT

PLAN FOR FURTHER DISSEMINATION AS WELL AS USE OF KNOWLEDGE AND RESULTS AFTER THE END OF THE PROJECT

I. PLAN FOR FURTHER DISSEMINATION

The consortium will be engaged in conducting further activities for promoting and disseminating the project results. The following measures are planned to follow up the project:

I.1. DURAMET WEBSITE

The DURAMET website will first of all be kept as an information source of the activities performed in the project. The website will also continue to receive and publish papers online related to the project. The website will be updated to reflect the current status of the project as finished. Reports and final results will be clearly communicated through relevant news items and reports.

I.2. JOURNAL PUBLICATIONS

Future academic articles and reports will be produced. This is an important component in the continuation of communicating the results from the research undertaken. The members of the project will target specifically relevant well-recognized academic journals for the future publications. The following publications are planned for publication:

WP2

POLITO

- **Protocol tests for DMFCs MEAs**, S. Specchia[a], A.H.A. Monteverde Videla[a], C. Francia[a], V. Baglio[b], A.S. Aricò[b], [a] Politecnico di Torino, [b] Consiglio Nazionale delle Ricerche, Istituto di Tecnologie Avanzate per l'Energia

WP3

CNRS

- **Innovative cost-effective direct methanol fuel cell membranes based on PFSA-blend membranes** (co-authored publication CNRS – FuMA-Tech – IRD Fuel Cells, Politecnico di Torino, CNR-ITAE
- **Sulfonated polyetheretherketone – zirconium phosphate: from membranes to stack**, co-authored publication CNRS – FuMA-Tech – IRD Fuel Cells, Politecnico di Torino, CNR-ITAE

CNR-ITAE

- **Influence of cross-over and selectivity on performance of direct methanol fuel cells,** co-authored publication CNR-ITAE, FuMA-Tech, CNRS

WP4

TUM

- **Bottom-up synthesis of carbon supported ZrO_2 nanoparticles from two different precursors**, P. Madkikar, X. Wang, T. Mittermeier, M. Piana, H. A. Gasteiger, TUM.
- **Zr-oxypthalocyanine Derived Electrocatalysts for the Oxygen Reduction Reaction,** T. Mittermeier, P. Madkikar, M. Piana, X. Wang, H. A. Gasteiger, TUM
- **Evaluation of Metal Silicides as non-PGM Anode Catalysts for Fuel Cells,** T. Mittermeier, X. Wang, P. Madkikar, H. A. Gasteiger, M. Piana, TUM

CNR-ITAE

- **Graphene-supported sub-stoichiometric sodium tantalate as methanol tolerant non-noble metal catalyst for the electro-reduction of oxygen,** David Sebastián, Vincenzo Baglio, Shuhui Sun, Ana C. Tavares, and Antonino S. Aricò, CNR-ITAE

POLITO

- **Varying the morphology of FeTMPPCl electrocatalysts by using different SiO_2 template promoting the Oxygen Reduction Reaction,** A.H.A. Monteverde, L. Osmieri, S. Specchia, Politecnico di Torino

WP5

POLITO

- **Freezing/Thawing cycles on DMFCS**, A.H.A. Monteverde Videla[a], G.G. Lenzi[b], C. Francia[a], S. Specchia[a], [a] Politecnico di Torino, Italy - [b] Universidade Tecnológica Federal do Paraná, Ponta Grossa – Brasil
- **3D Multi-physics modelling of a Direct Methanol Fuel Cell for analyzing internal phenomena**, N.S. Vasile, A.H.A. Monteverde Videla, S. Specchia, Politecnico di Torino
- **Validation and sensitivity analysis of 3D Multi-physics model of a Direct Methanol Fuel Cell for the evaluation and optimization of new materials**, co-authored publication, Politecnico di Torino, CNR-ITAE, FuMA-Tech, CNRS

WP6

CNR-ITAE

- **Assessment and cost-analysis of DMFC stacks based on novel components developed in the Duramet project,** co-authored publication CNR-ITAE, FUMATECH, IRD, CNRS, CRF

CRF

- **Structure and electronic properties of Ta2O5 (001) defective surface**, IRD, to be submitted to Physical Review B
- **Cost analysis and scale-up study for the production of a DMFC stack**, IRD, to be submitted to Fuel Cells.

I.3. CONFERENCE PRESENTATIONS

DURAMET partners will continue to disseminate the project results at conferences, in particular once IPR have been protected. The results shall continue to be conveyed through lectures and participation in relevant conferences.

TUM

- **Towards a Better Understanding of the Activity of ZrO_2 as non-PGM ORR Catalysts in Acidic Media,** M. Piana, T. Mittermeier, P. Madkikar, X. Wang, H. A. Gasteiger, 227th ECS Meeting – Chicago – 24-28 May 2015.

I.4. DURAMET BROCHURE

An update of the existing brochure will be made, including most non-confidential results. This updated brochure will be made available on the public website.

II. USE OF KNOWLEDGE AND RESULTS AFTER THE END OF THE PROJECT

II.1. POTENTIAL IMPACT

The market segments for DMFCs concern with portable generators, UPS and back-up power systems, and portable micro-fuel cells for specialist products. These are considered to be financially attractive for an emerging Fuel Cells European industry in the short term while being technically representative of power ranges and application requirements for which fuel cells can be used in other early-market applications. Direct methanol fuel cells are indeed particularly suited for auxiliary-power-units (APU) applications. Cars and other vehicles, from trucks to airplanes, have power requirements beyond those for propulsion. Auxiliary-power requirements are likely to grow significantly as developers incorporate additional electronics into vehicles. The power range of some hundreds Watts is suitable for devices such as weather stations, medical devices, signal units, APU's, gas sensors and security cameras. DMFCs will care for much longer power autonomy and will make possible to expand the use of different devices even in remote areas. Not only do they provide the potential to reduce pollution, energy use, and greenhouse gases, but they also provide the potential to reduce costs and to increase comfort since vibration and noise are reduced in several applications. They have been postulated as suitable systems for power generation in the field of portable power sources, remote and micro-distributed energy generation as well as for auxiliary power units (APU) in stationary and mobile applications. DMFCs utilize liquid fuel to deliver continuous power and they have low fuel storage and handling constraints than hydrogen fuelled fuel cells.

II.1.1. STEPS NEEDED TO BRING ABOUT THESE IMPACTS

In order to be competitive within the portable and distributed energy markets, the DMFCs must be reasonably cheap; they should be characterised by high durability and capable of delivering high power densities. Before these technologies can reach a full-scale production, specific problems have to be solved especially the high cost and the short-term stability. The results obtained in this project are dealing with

new cost-effective membranes showing better resistance than Nafion to methanol crossover as well as lower drag of Ru ions and excellent conductivity. Improved durability electro-catalysts have been developed with the aim to reduce costs, degradation and noble metals content. To validate the new membranes and electro-catalysts materials, specific development of membrane-electrode assembly have been carried out with tailored hydrophobic-hydrophilic electrode characteristics. The new developed components were thus validated in short stacks. Their performance and durability under practical operation have been assessed. The materials developed in Duramet appear appropriate for applications in advanced DMFC systems. The further steps needed to bring these impacts is the introduction of the novel materials into the next generation DMFC systems that are commercialised by the IRD partner for portable and distributed energy markets (including back-up power systems for telecommunications etc.) and the validation of the APU DMFC systems on board for transportation applications. The last task is undertaken by the partner CRF FIAT as end-user. Whereas, FUMATECH as chemical company has already started deployment of project results by including the new membrane products in their catalogue.

II.2. POTENTIAL IMPACT FOR INDUSTRIAL PARTNERS OF DURAMET

II.2.1. CRF

The technology developed in the project allows to decrease the cost and improve the durability of direct methanol fuel cell stacks. This can enable the construction of reliable and affordable auxiliary power units to be installed on special vehicles and trucks. The possible impact is related to the installation of 1-5kWh APU on commercial vehicles and caravans. The yearly production volume can be estimated to be 10000 units.

II.2.2. IRD

The gained knowledge about MEA's base on both novel membranes and novel catalyst will be used in the further development of both DMFC MEA's and systems based on these MEA's. On the short term the novel membranes developed will be further tested for durability and stability in IRD's DMFC system. The novel membranes have a promising cost potential that will make the IRD DMFC systems more competitive with respect to competing technologies like small diesel generator based APU's

II.2.3. FUMA

In the DURAMET project FUMATECH has developed a cost-effective membrane for DMFC applications. This membrane was successfully produced on the FUMATECH continuous production line with the aim to obtain high-quality and highly reproducible membranes for MEA development, evaluation and sampling. The process of the pilot-scale production of the novel DMFC membrane is fully compatible with the standard large-scale membrane production enabling the rapid transfer and integration of the new technology into the standard operation of manufacturing processes; which allows the subsequent commercialisation of project results. The potential impact for FUMATECH is related to a yearly membrane production of around 2000 m2 for 10000 units.

II.3. EXPLOITATION OF FOREGROUND

Six exploitable foregrounds, allowing several partners to promote and exploit Duramet research results, have been identified and are listed below (note that IPR exploitable measures have been and will be taken):

1. **CNR-ITAE:** ***Monopolar stack design for portable DMFC applications*** – Sector of application: Production of electricity - Patents and publications as planned measures for prior art defense
2. **CNR-ITAE:** ***Bipolar stack design for DMFC application in APU sytems*** – Sector of application: Production of electricity - Patents and publications as planned measures for prior art defense
3. **CNR-ITAE:** ***Non noble metal tantalum-based electrocatalyst for oxygen eduction in DMFCs***– Sector of application: Production of electricity - Patents and publications as planned measures for prior art defense
4. **FuMA-Tech:** ***New cost-effective membrane for DMFC***– Sector of application: Production of electricity - Patent being applied for.
5. **TUM:** ***Total replacement of Pt with acid-stable, valve-metal oxides as catalysts for the Oxygen Reduction Reaction (ORR) in fuel cells*** – Sector of application: Production of electricity and Other research and experimental development on natural sciences and engineering – No patent being applied for.
6. **IRD:** ***Improved knowlegde of state of the art DMFC MEA' materials, in particular withe respec to fabrication and operation of MEA's based on novel membranes*** – No patent being applied for.

II.4. EXPLOITATION OF FOREGROUND IN FUTURE COLLABORATION BETWEEN PARTNERS

The basis for future collaborations among the partners has been set. Cooperation between FUMATECH (membrane manufacturer) and IRD (DMFC system developer) has been programmed for the next future. It can be possible for IRD to include the new FUMATECH membranes in their systems especially if the cost is further reduced. At the present the FUMATECH membranes show much better characteristics than Nafion e.g. 60-70 % cost saving for the polymer, lower crossover corresponding to better fuel utilisation (energy/fuel saving) and excellent durability.

CRF FIAT will explore in the next period APU based on DMFC systems for transportation applications and will establish a strict cooperation with IRD in this field.

All partners will present their results to potential customers, in accordance with Consortium Agreement and IPR, to explore alternative utilisation in different fields. In fact, membrane, catalysts and stack design can have different applications ranging from ethanol fuel cells and hydrogen fuel cells to low temperature batteries and electrochemical sensors.

Further improvements for materials and devices appear necessary especially in terms of cost and further reduction of methanol permeation through the membrane. In this context, the partners can use the foreground to put the basis of collaboration in a next project.