



**CRITICAL RAW MATERIAL ELECTROCATALYSTS REPLACEMENT  
ENABLING DESIGNED POST-2020 PEMFC**

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 Project Coordinator: Deborah Jones –CNRS

**DELIVERABLE REPORT**

**DELIVERABLE 7.5 – Survey of dissemination activities and final plan for dissemination and exploitation of project results**

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**DISSEMINATION LEVEL**

<b>PU</b>	<i>Public</i>	<b>X</b>
<b>PP</b>	<i>Restricted to other programme participants (including the Commission Services)</i>	
<b>RE</b>	<i>Restricted to a group specified by the consortium (including the Commission Services)</i>	
<b>CO</b>	<i>Confidential, only for members of the consortium (including the Commission Services)</i>	

**NATURE OF THE DELIVERABLE**

<b>R</b>	<i>Report</i>	<b>X</b>
<b>P</b>	<i>Prototype</i>	
<b>D</b>	<i>Demonstrator</i>	
<b>O</b>	<i>Other</i>	

<b>SUMMARY</b>	
<b>Keywords</b>	Dissemination and Communication
<b>Abstract</b>	<p>The CRESCENDO consortium undertook numerous dissemination and communication activities throughout the duration of the project despite the pandemic that has mainly impacted the conference attendances and the networking activities in the second period of the project.</p> <p>CRESCENDO consortium was very successful in disseminating the project results, especially with the joint organisation of an international workshop with NMBP CREATE, the publication of 14 articles in peer-reviewed journals and 24 presentations at international conferences and workshops.</p> <p>Various target groups included industry, academia, government bodies and the public were reached.</p> <p>After the end of the project, the consortium will continue to carry out further activities to disseminate and exploit the results.</p> <p>The protection of intellectual rights of results issued from CRESCENDO project will still follow the agreed dissemination protocol, to ensure confidentiality and the legitimate interests of the partners, according to the Grant Agreement article II.30 and the internal dissemination protocol (D7.2).</p>
<b>Public abstract</b>	<i>Same as above</i>

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# SURVEY OF DISSEMINATION ACTIVITIES AND FINAL PLAN FOR DISSEMINATION AND EXPLOITATION OF PROJECT RESULTS

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## 1. INTRODUCTION

During the whole project duration, all the partners have been actively disseminating and communicating towards different target groups included industry, academia, government bodies and the public. However, those dissemination actions, particularly the participation to conferences and the networking, have been seriously impacted by covid-19, with all conferences from March 2020 until the end of the project having been cancelled or postponed, which explains the low level of conference attendances during the second period of the project.

The consortium will continue disseminating and exploiting the project results after the end of the project.

Of course, as is it the case since the beginning of the project, those upcoming activities with direct link to the results obtained in CRESCENDO will still be subjected to agreement between the partners, in order to protect the intellectual property rights, confidentiality and the legitimate interests according to the Grant Agreement article II.30 and the internal dissemination protocol (D7.2).

## 2. DISSEMINATION & COMMUNICATION ACTIVITIES

### 2.1. PROJECT WEBSITE

The project website (<https://crescendo-fuelcell.eu/>), fully operational since M4, gives an overview of the status and the progress of the project. It has been updated on a regular basis and it includes the most relevant information like public deliverable reports, publishable summaries of confidential deliverable reports, updates on dissemination activities and other project news, which were communicated to the public and the scientific community.

***The website will reflect the status of the project as finished but will remain fully active as an information source of the activities performed in the project and will continue to provide updated information like new publications, reports and final results which will be clearly communicated through relevant news items.***

### 2.2. BROCHURE, NEWSLETTER AND POSTER

Three different types of communication supports were designed and edited in agreement with all the partners, and all are available from the public website.

Furthermore, to reach more readers and improve their impact, they were distributed to the partners for their use during attendance at conferences and technical fair events as well as distributed through partner's LinkedIn accounts.

- Project brochure: ([Brochure PDF to download](#)).
- An annual newsletter
  - [Newsletter issue#1 PDF to download](#)
  - [Newsletter issue#2: PDF to download](#)
- Poster: a poster presented the project was prepared and presented during a workshop. It was used by partners when needed and is available on the PSW and on the public website. [PDF](#)

***The CRESCENDO consortium will continue to communicate on its main achievements; effectively, a third newsletter will be released by the end of 2021.***

***As for the previous issues, this third newsletter will be available from the public website and relayed on LinkedIn through the partners' accounts.***

### 2.3. CONFERENCE PRESENTATIONS

CRESCENDO partners have disseminated project results at conferences through oral and poster presentations including:

- **Online 29th Topical Meeting of the International Society of Electrochemistry, 18-21 April 2021**
  - UNIPD oral presentation: Effect of induced Micro- and Meso-porosity on the formation and activity of Fe-N-C active sites for Oxygen Reduction Reaction

- **EFCD2019, 15-18 September 2019, La Grande Motte, France**
  - TUB keynote: PGM-poor and PGM-free ORR Fuel Cell Electrocatalysts
  - TUB poster presentation: Confined Pyrolysis Synthesis of Fe-Coordinated Nitrogen-Doped Carbon Catalysts with Surface-Rich Fe-N<sub>x</sub> Moiety to Boost the Oxygen Reduction Reaction in Acidic Media
  - TUB poster presentation: Influence of carbon support modification on non-noble MNC catalysts for the oxygen reduction reaction
  - CEA oral presentation: Non-covalent Integration of a Ni based Molecular Catalyst to Graphene Acid for Efficient, Noble-metal Free, Electrocatalytic H<sub>2</sub> Oxidation
  - CEA poster presentation: Performances of ionomer-containing bio-inspired hydrogen fuel cell anodes: an interplay between surface chemistry and self-assembly at the mesoscale
  - CNRS oral presentation: CRESCENDO: Critical Raw material Electrocatalysts replacement ENabling Designed pOst-2020 PEMFC
  - CNRS poster presentation: Platinum Free Cathode: Development of a Chemically Regenerative Redox Fuel Cell
  - CNRS poster presentation: Activity-stability relation for iridium oxide nanoparticles deposited on doped tin oxide nanofibres as oxygen evolution catalysts for PEM water electrolysis
  - ICL oral presentation: Increasing Population of Oxygen Reduction Active Sites in Fe-N/C Catalysts
  - UNIPD oral presentation: What Core@shell Model Studies can Teach us About Electrocatalysis?
  - UNIPD poster presentation: Converting mixed plastics into mesoporous Fe-N-C electrocatalyst active for oxygen reduction reaction in acidic electrolyte: the continuing challenge of active site formation and characterization
- **International Society of Electrochemistry Annual Meeting, Durban, South Africa, 4-9 August 2019**
  - CNRS, TUB, ICL, UNIPD, JMFC joined presentation: *Increased Understanding of non-PGM Catalysts for PEMFC Cathodes*
- **Electrochemical Conference on Energy and the Environment: Bioelectrochemistry and Energy Storage, July 21-26, 2019, Glasgow, Scotland**
  - CNRS invited presentation: *Iron-nitrogen moieties embedded in a carbon matrix as bio-inspired electrocatalytic sites for dioxygen electroreduction in fuel cells*
  - CEA presentation: *Noble metal free molecular based anode for H<sub>2</sub>-O<sub>2</sub> fuel cell*
- **235<sup>th</sup> ECS meeting, 26-30 May 2019, Dallas, USA**
  - CNRS poster presentation: *Chemically Regenerative Redox Fuel Cell as Alternative to Conventional Proton Exchange Membrane Fuel Cell*
- **25th Topical Meeting of the International Society of Electrochemistry, New electrochemical processes for energy, and the environment 12-15 May 2019, Toledo, Spain**
  - University of Padova oral presentation: *Converting mixed plastics into mesoporous Fe-N-C electrocatalyst for energy devices*
  - University of Padova poster presentation: *Effect of different iron precursors on catalytic performance of Fe-N-C Catalysts for ORR PEMFC*
- **FCH JU PEMFC development workshop, 5-6 March 2019, Marseille, France**
  - All partners poster presentation: *CRESCENDO - Critical Raw material Electro-catalysts replacement ENabling Designed pOst-2020 PEMFC*
- **Electrochemical Discussions - Latest insights on PGM-free catalysts for Energy systems and Fuel Cells, 8th Feb. 2019 Turin, Italy**
  - CNRS, TUB, ICL, UNIPD, JMFC poster presentation: *Identification of the Site Density and Turnover Frequency of Fe-N-C Catalysts and of PEMFC Performance Limitations of Fe-N-C Catalyst Layers.*
  - ICL oral presentation: *Counting active sites and estimating turnover rates in Fe-C/N catalysts.*
- **Groupe Français de Bioélectrochimie - GFB 2018, 24-27 September 2018, Sète, France**
  - CEA presentation: *Noble metal free molecular based anode for H<sub>2</sub>-O<sub>2</sub> fuel cell*

- **ISE meeting, Bologna, 3-5 September 2018, Italy**

- UNIPD poster presentations:
  - *Influence of Iron Complex Precursor on the Active Site Density in Fe-N-C Catalysts for ORR in PEMFC*
  - *Soft Template Synthesis of Fe-N-C Catalysts for ORR from Fe-Chelating Polymers*
- UNIPD oral presentation
  - *Highly Graphitized Fe-Nitrogen Doped Carbon Derived from Biomass as Electrocatalyst for Oxygen Reduction Reaction*

## 2.4. PUBLICATIONS

- *ACS Appl. Mater. Interfaces*, 2021, 13, 42693–42705: Sulfur Doping versus Hierarchical Pore Structure: The Dominating Effect on the Fe-N-C Site Density, Activity, and Selectivity in Oxygen Reduction Reaction Electrocatalysis, G. Daniel, M. Mazzucato, R. Brandiele, L. De Lazzari, D. Badocco, P. Pastore, T. Kosmala, G. Granozzi, and C. Durante
- *Catalysts* 2021, 11(3), 390; Highly Graphitized Fe-N-C Electrocatalysts Prepared from Chitosan Hydrogel Frameworks, G. Daniel, T. Kosmala, F. Brombin, M. Mazzucato, A. Facchin, M. C. Dalconi, D. Badocco, P. Pastore, G. Granozzi, and C. Durante
- *Appl. Catal. B: Environmental*, 2021, 291, 120068: Effect of induced Micro- and Meso-porosity on the formation and activity of Fe-N-C active sites for Oxygen Reduction Reaction, M. Mazzucato, G. Daniel, A. Mehmood, T. Kosmala, G. Granozzi, A. Kucernak, C. Durante
- *Appl. Catal. B: Environmental*, 2021, 292, 120169, Deactivation, reactivation and super-activation of Fe-N/C oxygen reduction electrocatalysts: gas sorption, physical and electrochemical investigation using NO and O<sub>2</sub>, P. Boldrin, D. Malko, A. Mehmood, U. I. Kramm, S. Paul, N. Weidler, A. Kucernak
- *Chem. Catal.*, 2021, 1, 88-105, Impact of ionomer structuration on the performance of bio-inspired noble- metal-free fuel cell anodes, N. Coutard, B. Reuillard, T. Ngoc Huan, F. Valentino, R. T. Jane, S. Gentil, E. S. Andreiadis, A. Le Goff, T. Asset F. Maillard, B. Jusselme, A. Morozan, S. Lyonard, V. Artero and P. Chenevier
- *Nature Catal.*, 2021, 4, 10–19, Identification of Durable and Non-Durable Fe<sub>Nx</sub> Sites in Fe-N-C Materials for Proton Exchange Membrane Fuel Cells, J. Li M.-T. Sougrati, A. Zitolo, J. Ablett, I. C. Oguz, T. Mineva, I. Matanovic, P. Atanassov, A. di Cicco, K. Kumar, L. Dubau, F. Maillard, F. Jaouen
- *Electrochimica Acta*, 2020, 362, 137200, Upcycling of polyurethane into iron-nitrogen-carbon electrocatalysts active for oxygen reduction reaction, G. Daniel, T. Kosmala, M. C. Dalconi, L. Nodari, D. Badocco, P. Pastore, A. Lorenzetti, G. Granozzi, and C. Durante
- *Chem. Soc. Rev.*, 2020, 49, 6605-6631, A comparative perspective of electrochemical and photochemical approaches for catalytic H<sub>2</sub>O<sub>2</sub> production, Y. Sun, L. Han and P. Strasser
- *Energy Environ. Sci.*, 2020, 13, 2480-2500, Establishing reactivity descriptors for platinum group metal (PGM)-free Fe–N–C catalysts for PEM fuel cells, M. Primbs, Y. Sun, A. Roy, D. Malko, A. Mehmood, M.-T. Sougrati, P.-Y. Blanchard, G. Granozzi, T. Kosmala, G. Daniel, P. Atanassov, J. Sharman, C. Durante, A. Kucernak, D. Jones, F. Jaouen and P. Strasser
- *ACS Catal.* 2020, 10, 14, 7475–7485, Stable, Active and Methanol Tolerant PGM-free Surface in Acidic Medium: Electron Tunneling at Play in Pt/FeNC Hybrid Catalysts for Direct Methanol Fuel Cell Cathode, T. Kosmala, N. Bibent, M.-T. Sougrati, G. Drazic, S. Agnoli, F. Jaouen, and G. Granozzi
- *ACS Appl. Mater. Interfaces* 2020 12, 5805–5811, Noncovalent Integration of a Bioinspired Ni Catalyst to Graphene Acid for Reversible Electrocatalytic Hydrogen Oxidation, B. Reuillard, M. Blanco, L. Calvillo, N. Coutard, A. Ghedjatti P. Chenevier, S. Agnoli, M. Otyepka, G. Granozzi, V. Artero
- *ACS Catal.*, 2019, 9, 9359-9371, Understanding Active Sites in Pyrolyzed Fe–N–C Catalysts for Fuel Cell Cathodes by Bridging Density Functional Theory Calculations and <sup>57</sup>Fe Mössbauer Spectroscopy, T. Mineva, I. Matanovic, P. Atanassov, M.-T. Sougrati, L. Stievano, M. Clémancey, A. Kochem, J.-M. Latour, and F. Jaouen

- *ACS Catal.* 2019, 9, 4841–4852, Accurate Evaluation of Active-Site Density (SD) and Turnover, Frequency (TOF) of PGM-Free Metal–Nitrogen-Doped Carbon (MNC) Electrocatalysts using CO Cryo Adsorption, F. Luo, C. Hyuck Choi, M. J.M. Primbs, W. Ju, S. Li, N. D. Leonard, A. Thomas, F. Jaouen, and P. Strasser
- *Johnson Matthey Technology Review*, 62, 231-255, Toward Platinum Group Metal-Free Catalysts for Hydrogen/Air Proton-Exchange Membrane Fuel Cells, Jaouen, F.; Jones, D.; Coutard, N.; Artero, V.; Strasser, P.; Kucernak, A.

**The CRESCENDO consortium will continue to publish the results obtained during the project. For the moment, 1 other manuscript has been submitted:**

- *Nature Mater.* Identification of durable and non-durable FeN<sub>x</sub> sites in Fe-N-C materials for proton exchange membrane fuel cells, J. Li, M. Tahar Sougrati, A. Zitolo, J.M. Ablett, I. Can Oğuz, T., Mineva, I. Matanovic, P. Atanassov, A. Di Cicco, K. Kumar, L. Dubau, F. Maillard and F. Jaouen

## 2.5. CONFERENCE ORGANISATION

### Organisation of an international conference - EFCD2019: Electrolysis and Fuel Cell Discussions - Towards Catalysts Free of Critical Raw Materials for Fuel Cells and Electrolysers



The joint CRESCENDO-CREATE conference, Electrolysis and Fuel Cell Discussions - Towards catalysts free of Critical Raw Materials for fuel cell – EFCD2019 was held in La Grande Motte, France from 15-18 September 2019. This conference brought forward deliverable D7.4 by several months.

- The conference website was released in July 2018: [www.efcd2019.eu](http://www.efcd2019.eu)
- A flyer announcing the event was edited and distributed during various conferences.
- 125 abstracts were received, and the conference programme included 34 oral presentations, 11 keynote lectures and 84 posters.

## 2.6. NETWORKING

### International cooperation with IPHE countries

- **EFCD2019, 18th September 2019, La Grande Motte France:** Meeting between IPHE associate partners from the USA (Electrocatalysis consortium, P. Atanassov and I. Zenyuk), the Israeli FC consortium (L. Elbaz), the FCH JU PEGASUS and CRESCENDO projects
- **Electrochemical Discussions – “non-PGM workshop”, 7th Feb. 2019 Turin, Italy:** Meeting between CNRS, ICL, UNIPD, UC Irvine, and Bar Ilan University
- **GRC fuel cells, July 29 - August 3, 2018, USA:** Meeting between IPHE associate partners from the USA (Electrocatalysis consortium (D. Myers, P. Atanassov, K. Artyushkova, I. Zenyuk) and CRESCENDO partners: CNRS, JMFC, ICL, TUB

### European networking

- **EFCD2019, 18th September 2019, La Grande Motte France:** European funded project dedicated session with PEGASUS (FCH JU), CRESCENDO (FCH JU) and CREATE (H2020) projects
- **INSPIRE workshop, 5-6 March 2019, Marseille, France – CRESCENDO poster presentation:** The workshop combined several FCH JU H2020 projects focused on PEM fuel cell components together for poster sessions, forums and project presentations. Projects represented: CRESCENDO, DIGIMAN, Fit-4-AMANDA, GAIA, GRASSHOPPER, HYDRAITE, ID-FAST, INSPIRE, MAMA-MEA and VOLUMETRIQ

## 2.7. OUTREACH ACTIVITIES

- **19 June 2021**, The TV Channel “Deutsche Welle”, came to visit the Peter Strasser’s laboratory at TU Berlin to produce a report on “*Opportunities and Challenges of green hydrogen and CO<sub>2</sub> electrolysis*”. The Documentary will be broadcast in Latin America area (Middle and South America) and will be available by early November 2021.
- **18 June 2021**, the TU Berlin news outlet produced a Photo shooting of CO<sub>2</sub> electrolyzer equipment at Peter Strasser’s laboratory to showcase their lines of research in renewable energy and synthetic fuels and chemicals. This publication will appear in print in the next journal issue in October 2021.

## 3. EXPLOITATION OF RESULTS

### BMW

The overall results of CRESCENDO with regards to the performance, durability, and cost of PGM-free MEAs, was a great starting point for BMW to evaluate the current status and readiness level of PGM-free fuel cell technology. It was made clear that the technology is not mature enough for automotive applications in the near future and that further development of these materials is required. BMW will use the results obtained in CRESCENDO as a baseline for comparison with future generation of PGM-free MEAs and monitor the progress of upcoming new materials for potential use in automotive applications.

### JMFC

The work in WP5 has helped JMFC to understand in greater detail the needs of the automotive industry and the types of solutions that are required for the use of non-PGM cathodes. The scale-up of non-PGM catalysts from less than 1 g to tens of gram scale within CRESCENDO has also brought useful validation processes to the fore with respect to safety and process-friendly chemistry. New catalyst approaches introduced within the project in WP3 could also form the basis of future developments and inventions.

## 4. CONCLUSION AND FUTURE WORK

During the second period of the project, the CRESCENDO consortium activities has been seriously impacted by covid-19, with all conferences from March 2020 until the end of the project having been cancelled or postponed. This situation has particularly impacted the number of conference attendances as well as the possibility for the consortium to conduct face-to-face networking meetings. Nevertheless, during the same period, the project partners have still been able to actively disseminate the project results, mainly through publications.

It is also important to highlight that given the pandemic that followed, it was particularly beneficial that the joint organisation of an international workshop with NMBP CREATE was brought forward to September 2019 (from its original delivery date of September 2020). With this, and the publication of 14 articles in peer-reviewed journals and 24 presentations at international conferences and workshops, the CRESCENDO consortium was very successful in disseminating the project results.

The partners will continue implement dissemination and communication measures depending on the latest results obtained. This will be achieved through:

- A third edition of the newsletter
- An update of the public website: it will continue to receive and provide information on published papers related to the project. Reports and final results will be clearly communicated through relevant news items and reports.
- Publications in peer-reviewed journals

Finally, partners will undertake all the necessary measures to exploit the project results, in particular through further research and development activities.