Newsletter
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FCH JU Awards 2019, Brussels, Belgium
CRESCENDO Best Success Story

Last year's Best Success Story winner: ***'Driving forward fuel cell technologies'***, involves 5 projects, **CRESCENDO**, VOLUMETRIQ, INSPIRE, GAIA and PEGASUS.

The successful projects consider reduction and replacement of critical raw materials, reduce fuel-cell technology production costs, speed up manufacturing, develop new materials to increase fuel-cell performance and demonstrate how people can rely on hydrogen energy. Overall, they pave the way for a world-class European fuel-cell industry that sustains clean energy. The Awards were presented at a ceremony at the Royal Museums of Fine Arts in Brussels on 20 November 2019, attended by more than 300 industry, research and EU representatives.

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Partners

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CRESCENDO

Critical Raw material ElectrocatalystS
replaCement ENabling Designed
pOst-2020 PEMFC

CRESCENDO IS A 3 YEAR EU SUPPORTED PROGRAMME TO DEVELOP HIGHLY ACTIVE AND STABLE NON-PGM ELECTROCATALYSTS FOR AUTOMOTIVE PEMFC AND TO RE-DESIGN THE CATHODE CATALYST LAYER

Edito

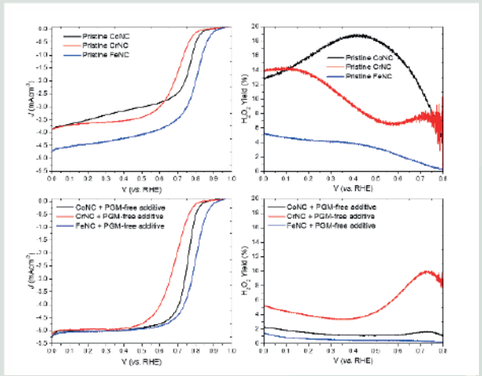
The project team is tackling, head-on, the crucial bottlenecks in non-PGM fuel cell catalysis by developing new methodologies for determination of catalyst descriptors hitherto not considered, in parallel to new catalyst development, new approaches to catalyst stabilisation and cathode catalyst layer design specific to non-PGM catalysts, and development of bioinspired anode catalysts. Amongst recent highlights that are the focus of this issue, is the progress in PGM-free catalyst stabilisation using sacrificial and regenerative scavengers for reactive oxygen species. One of these approaches enabled the consortium to reach the project milestone on proven strategies to improve durability. This result is probably the first demonstration of the rational stabilisation of PGM-free metal-NC catalyst by a PGM-free co-catalyst, and potentially opens up a rich landscape of PGM-free co-catalysts with improved stability during PEMFC operation. The partners continue to make steps onward and upward in PGM-free cathode catalyst development. An unusually high iron content catalyst comprising only isolated metal sites has excellent potential for facilitating catalyst layer construction, while a further novel route to catalyst development has allowed the group to move to within 0.15 V of the project final cell voltage target at 600 mA/cm^2 in an MEA (hydrogen - air). For the anode, a new type of anchoring for bioinspired nickel-based catalysts has given a leading current density of 60 mA cm^{-2} at 0.1 V overpotential, which opens up perspectives for a PGM-free fuel cell within the project timescale.

We are advancing *crescendo* !!

Main Achievements

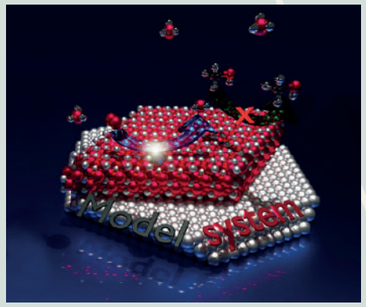
Selectivity improvement with catalyst stabilisation additive

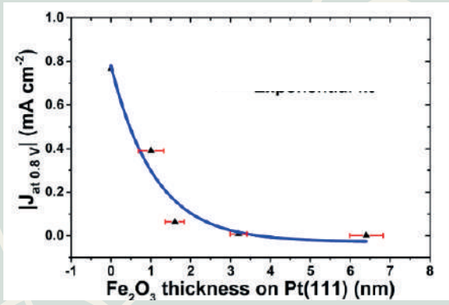
In WP4, a novel PGM-free co-catalyst has been developed by CNRS which when combined with PGM-free MNC catalysts greatly reduces the side production of H_2O_2 during ORR and improves PEMFC stability. This additive is effective for all MNC catalysts (Fe, Co, Cr, etc.) which demonstrates a considerable advancement in reaction engineering based approaches for improved MNC catalyst stability in PEMFCs. Free of critical raw materials and easily synthesised using conventional techniques, this additive brings exciting new chemistry to PGM-free PEMFCs in terms of both scientific discovery and practical application.



Fe_2O_3/Pt core shell catalysts

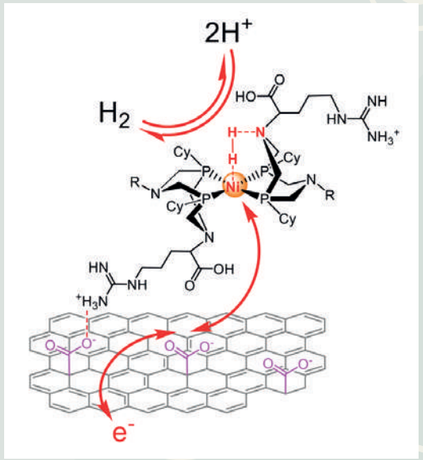
In WP4, the surface studies performed at University of Padova contributed to the understanding of the influence of ultra-low amounts of platinum on the stabilisation and catalytic activity of Fe-NC catalysts. Ultrathin Fe_2O_3 films on Pt(111) were prepared which represent a model system for the core-shell $Pt@FeO_x$ structure found in powder Pt-FeNC catalysts. Surprisingly, the Fe_2O_3 films grown on the Pt(111) surface were found to be stable in acidic medium, inactive for methanol oxidation and their specific activity for ORR increases exponentially with decreasing thickness of the Fe_2O_3 overlayer. The phenomenon can be explained by an electron-tunnelling effect of Pt electrons through the Fe_2O_3 film, influencing both the stability of the overlayer and its activity.





Leading mass activity bioinspired catalyst

Efforts in WP6 have mainly focused on the integration of Ni-based molecular catalyst directly inspired by the structure of the active site of hydrogenases in the anode catalytic layer.



Researchers from CEA and University of Padova succeeded in combining graphene-based material and the bio-inspired catalyst, generating a novel anode design. Electrostatic interactions between the carboxylic acid residues of the graphenic acid and the guanidinium moieties present on the catalyst ligand allow the catalyst loading to be controlled and high currents densities above 30 mA cm^{-2} at 0.4 V vs RHE were obtained, setting up new benchmark for molecular HOR.

In parallel, a new anode material was designed involving non-covalent functionalisation of carbon nanotubes. This allowed the partners to reach record current densities of 60 mA cm^{-2} at 0.1 V overpotential and at room temperature, very close to the ambitious CRESCENDO project target of 75 mA cm^{-2} at 0.1 V overpotential.

Future work will include implementing these non-PGM active materials in operational fuel cell configuration.

Breaking the iron solubility limit in Fe-NC catalysts

As a part of WP3, significant efforts were devoted to developing novel synthesis approaches to substantially increase the density of atomic iron sites in Fe-NC catalysts. The new Fe-NC catalyst developed at Imperial College London contains 7 wt.% atomically dispersed iron which is more than twice the highest value of up to 3 wt.% reported in the literature for these catalysts. ^{57}Fe Mössbauer spectra obtained at 5K show exclusive existence of all 7 wt.% iron as FeN_4 sites.