Low loading CRM and CRM - free electrocatalysts as new cost – effective strategy in PEMWE

Abstract topic 2

To achieve cost-effective green hydrogen production by proton exchange membrane (PEM) water electrolysis (WE), it is necessary to minimize the use of high-cost metal electrocatalysts. In a PEM electrolysis system, one of the most studied nowadays for water splitting, the membrane electrode assembly (MEA) typically consists of an iridium and/or ruthenium catalytic layer at the anode side for the oxygen evolution reaction (OER), a platinum-based catalytic coating at the cathode side for the hydrogen evolution reaction (HER) and a proton-exchange polymer membrane, characterized by perfluorosulfonic acid (Nafion® or Aquivion®). The high costs of the noble materials used as catalysts ("critical raw materials", CRM) and the supply risks due to scarcity and environmental problems are the disadvantages to overcome to reduce the costs of PEM technology. Therefore, in order to minimize the use of expensive materials, this work aims to evaluate non-critical raw materials as possible candidate for catalyzing the OER and the HER, such as silver on advanced conductive electro-ceramic supports based on Ti oxide nanoparticles (Ti- suboxides, Ti_nO_{2n-1}, with Magneli phase) for the anode side and MoS_2 (1 mg_{MoS2} cm^{-2}) on carbon black for the cathode side. Another strategy to reduce the amount of CRM involves reducing noble metal catalysts to a level comparable to that of automotive fuel cells (<0.2 mg cm^{-2}, <50 €/kW) which have already achieved the marketing step. The new active materials under study are based on supported Ir or Ru nanophases, with low CRM content, such as IrRuOx/ Ti_nO_{2n-1} (30:70 at%) for the anode and a low loading Pt on carbon (0.5 mg_{Pt}/ cm^2) for the chatode.
In this work, the synthesis and physical chemical characterizations of these new electrocatalysts were evaluated, by means of XRD, XPS, SEM-EDX and BET analysis. Moreover, electrochemical characterizations, including polarization curves, impedance spectroscopy analysis, EIS, at 1.8V, 2V and 2.2V in a different range of temperature (30 – 80 °C) and stability tests were investigated to assess the performance and durability of these electrocatalysts in PEM electrolyzer.

Curriculum Vitae

Dr. Nicola Briguglio (male) has been working in the energy field at Italian National Council of Research (CNR), Institute for Advanced Energy Technologies (ITAE) since 2005. In 2008 he received a PhD degree from University of Messina with a thesis titled: “Simulation Tools for Hydrogen Production from Renewable Energy”. Presently, he works at the CNRTAE Institute “Nicola Giordano” in Messina as senior researcher. In particular, dr. Nicola Briguglio is a member of "Electrochemical Processes for Energy Conversion" and “Advanced Energy and Transportation Systems” groups at the CNR-ITAE Institute. He is involved in research programs related to the development of energy technologies and have developed prototypes of PEM electrolysis system and batteries (Zebra and vanadium Vanadium flow battery).

Competences of Dr. Briguglio cover technical evaluations of Life Cycle Assessment and CFD analysis He is referee for the International Journal of Hydrogen Energy and Fuel Processing Technology. He is the author of several international publications, technical reports, oral presentations at international congresses and contributions in books about hydrogen technologies. He has been professor in master and specialist courses about hydrogen technologies. He is involved in different European and National research Projects in Fuel cells, PEM Electrolysis and Batteries. He has participated in research activities, both experimental and theoretical, in the fields of hydrogen production from renewable energy by PEM electrolysis and the use of fuel cells in automotive and stationary applications. He has been involved in the training of Ph.D. students and he has taught national and international courses. He was involved in contracts with FIAMM for the development of batteries and Tozzi Renewable energies for the development of PEM electrolysers.

Scientific activity is currently addressed towards the following points reported below:

• Development of systems for Polymer Electrolyte Fuel Cell (PEFC);

• Studies on hydrogen production from renewable energy system: PEM Electrolyzer;

• Development of PEM Electrolyzer systems and stack;Electrochemical characterization of innovative materials and components in single cell configuration and short stack;

• Development of components and stacks for REGEBRATIVE Fuel Cell;

List of most relevant European project partecipations on electrolysis:

ELECTROLIFE *G.A. 101137802 ENHANCE KNOWLEDGE ON COMPREHENSIVE ELECTROLYSERS TECHNOLOGIES DEGRADATION THROUGH MODELING, TESTING AND LIFETIME PREVISION, TOWARD INDUSTRIAL IMPLEMENTATION*

HORIZON HYSCALE *G.A. 101112055 ECONOMIC GREEN HYDROGEN PRODUCTION AT SCALE VIA A NOVEL, CRITICAL RAW MATERIAL FREE, HIGHLY EFFICIENT AND LOW-CAPEX ADVANCED ALKALINE MEMBRANE WATER ELECTROLYSIS TECHNOLOGY*

H2020 ADVANCEDPEM *G.A. 101101318. Advanced High Pressure and Cost-Effective PEM Water Electrolysis Technology*

H2020 FCH JU NEPTUNE *- G.A. 779540 Next Generation PEM Electrolyser under New Extremes*

H2020 FCH JU ANIONE *G.A. 700008 Anion Exchange Membrane Electrolysis for Renewable Hydrogen Production on a Wide-Scale*

H2020 PROMETH2 *862253 Cost-effective PROton Exchange MEmbrane WaTer Electrolyser for Efficient and Sustainable Power-to-H2 Technology*

H2020 FCH JU HPEM2GAS *G.A. 700008 High Performance PEM Electrolyzer for Cost-effective Grid Balancing Applications*

FP7 FCH JU Project Electrohypem *300081 Enhanced performance and cost-effective materials for long-term operation of PEM water electrolysers coupled to renewable power sources*