

Maximizing the efficiency of Ir-based oxygen evolution electrocatalysts through Ni doping

Anna Giulia Cardone^{1,2}, Fabrizio Pirri^{1,2}, <u>Marco Etzi^{*,1}</u>

¹ Istituto Italiano di Tecnologia, Center for Sustainable Future Technologies, Via Livorno 60, 10144, Torino, Italy. ² Politecnico di Torino, Dept. of Applied Science and Technology, Corso Duca degli Abruzzi 24, 10129, Torino,

> Italy. * marco.etzi@iit.it

Significance and Relevance

This study presents novel Ir-TM (transition metal) catalysts for the Oxygen Evolution Reaction (OER) in acidic media, aiming to reduce the use of noble metals while enhancing performance. The key result is the higher catalytic activity of the mixed Ir-Ni alloy compared to pure Ir and IrO₂, attributed to changes in the crystalline and/or electronic structure and electrochemical surface area. This work provides a path toward more efficient and cost-effective OER catalysts for Proton-Exchange Membrane Electrolyzers (PEMs), addressing the scalability and sustainability challenges.

Preferred and 2nd choice for the topic:

- 1) H2 storage and transportation, green H₂ production, hydrogen vectors;
- 2) Sustainable and clean energy production and transport.

Preferred presentation: Oral preferred or Short Oral

Introduction and Motivations

The Oxygen Evolution Reaction (OER) is regarded as the bottleneck in electrochemical water splitting due to its slow kinetics. Currently, IrO₂ is the only material that offers the necessary activity and stability to function as an OER catalyst in the acidic environment of Proton Exchange Membrane (PEM) electrolyzers. For large-scale implementation, it is crucial to reduce the loading of noble metals in the catalyst composition as much as possible.¹ Introducing other transition metals, in the composition offers several possibilities to boost the performance of OER catalysts by changing their crystalline and electronic structure, as shown in our previous study on mixed Ir-Mn catalysts.²

Materials and Methods

Catalysts were prepared by thermal decomposition or by an innovative microwave synthesis. The crystalline structure, the morphology and composition, and the electronic structure were analyzed by X-ray diffraction (XRD), Field Emission Scanning Electron Microscopy (FE-SEM), Energy Dispersive X-Ray Spectroscopy (EDX), and X-Ray Photoelectron Spectroscopy (XPS). The electrocatalysts were tested in a three-electrode cell using an acidic electrolyte to assess their activity and stability.

Results and Discussion

Microwave synthesis is a fast and scalable process for the fabrication of electrocatalysts. As opposed to thermally prepared materials, which are mainly in the form of oxides,³ this synthesis led to the formation of metallic alloys.

Both doped and undoped Ir-based catalysts have higher catalytic activity as compared to a commercial IrO_2 catalyst. Doping Ir with Ni further increased the catalytic activity, resulting in higher current densities in Linear Sweep Voltammetry (LSV) (Figure 1) and lower Tafel slope. The higher activity of mixed catalysts is maintained after a stability test; undoped and doped Ir-Ni catalysts exhibit similar trends of current densities but they were shifted to higher values for the mixed catalysts (Figure 2). Indepth characterization of the fresh and used catalyst evidenced differences in morphology and composition.





Figure 1. Linear Sweep Voltammetry of the catalysts.



Figure 2. Chronoamperometry at E = 1.6 V vs. RHE.

References

- (1) Vesborg, P. C. K.; Jaramillo, T. F. Addressing the Terawatt Challenge: Scalability in the Supply of Chemical Elements for Renewable Energy. *RSC Adv.* **2012**, *2* (21), 7933–7947. https://doi.org/10.1039/c2ra20839c.
- (2) Etzi Coller Pascuzzi, M.; Hofmann, J. P.; Hensen, E. J. M. Promoting Oxygen Evolution of IrO2 in Acid Electrolyte by Mn. *Electrochim. Acta* 2021, *366*, 137448. https://doi.org/10.1016/j.electacta.2020.137448.
- Etzi Coller Pascuzzi, M.; Goryachev, A.; Hofmann, J. P.; Hensen, E. J. M. Mn Promotion of Rutile TiO<inf>2</Inf>-RuO<inf>2</Inf> Anodes for Water Oxidation in Acidic Media. *Appl. Catal. B Environ.* 2020, 261. https://doi.org/10.1016/j.apcatb.2019.118225.

Acknowledgments

The authors acknowledge the Project "Network 4 Energy Sustainable Transition—NEST", Spoke 4, Project code PE0000021, funded under the National Recovery and Resilience Plan (NRRP), Mission 4, Component 2, Investment 1.3— Call for tender No. 1561 of 11.10.2022 of Ministero dell'Universita` e della Ricerca (MUR); funded by the European Union—NextGenerationEU.