The World conference on Carbon 2025

Development of hollow bimetallic catalysts supported on nanostructured carbons for sustainable PEM fuel cell electrodes

Ali HAIDER[1,2], Loic NOUMBI[1], Lucas ELVIRA[2], Sophie HERMANS[2], Nathalie JOB[1]

[1]University of Liège, Department of Chemical Engineering (B6a), Allée du 6 Août 11, 4000 Liège, Belgium

[2]UCLouvain, IMCN Institute, Place Louis Pasteur 1 - bte L4.01.03, 1348 Louvain-la-Neuve, Belgium.

Email :Ali.haider@uliege.be

Proton Exchange Membrane (PEM) fuel cells offer an efficient method to convert hydrogen and oxygen into electricity and water, making them a promising solution for clean energy production. The catalytic layers of a PEM fuel cell are typically composed of Pt nanoparticles (NPs, ~3 nm in size) supported on carbon black and mixed with a polymer ionomer (Nafion®) [1]. However, upon operation, both the carbon support and the Pt nanoparticles degrade [2]: carbon undergoes oxidation, while Pt particles coalesce or dissolve and redeposit elsewhere (e.g., in the membrane), resulting in performance decline.

To enhance catalyst efficiency and lifetime, research has focused on developing alloys and more stable metal nanostructures, especially at the cathode side. Alloying Pt with transition metals such as Co or Ni contracts the Pt lattice, widening the d-band and lowering the reaction activation energy.This modification reduces the binding energy of oxygen reduction intermediates, which accelerates the reaction [3]. For support material, carbon xerogels (CXs) present an interesting alternative to carbon blacks; Indeed, diffusion-induced voltage losses (η_{diff}) can be significantly reduced by selecting CXs with appropriate pore textures [4].

The main goal of this project is to rationalize the complex synthesis method for hollow PtCo/CX catalysts to optimize it [5]. Additionally,metal loading (currently 10 wt.% Pt) will be increased to reduce the final cathode thickness. Catalysts were thus prepared on CXs with tailored pore textures (pore sizes ranging from 50 to 100 nm) and modified by depositing a graphitic carbon layer via Chemical Vapor Deposition (CVD). Graphitized surfaces are more resistant to corrosion, which helps stabilizing metal NPs and minimizes the electrode electrical resistance. Advanced characterization techniques, including XRD, HR-TEM, XPS, and ICP-AES, were used to analyze the morphological and compositional changes of the catalysts upon use.

The initial performance of hollow PtCo/CX catalysts was evaluated using electrochemical techniques such as cyclic voltammetry, CO stripping and ORR measurements on rotating disk electrode. In a further step, electrochemical characterization and Accelerated Stress Tests (ASTs) will be performed in complete Membrane-Electrode Assemblies (MEAs).

References

[1] Laurent-Brocq, M. et al. *Appl Catal B* 147, 453–463 (2014).

[2] Castanheira, L. *et al*. *ACS Catal* 5, 2184–2194 (2015).

[3] Hu, X. *et al*. *Energy & Fuels* 37, 11532–11566 (2023).

[4] Job, N.et al. *Energy Convese and Manage* 49, 2461–2470 (2008).

[5] Zubiaur, A. PhD thesis, University of Liege ,2017.