INVITED ORAL PRESENTATION

Optimization of transport in gas-diffusion electrodes for proton-exchange membrane fuel cells

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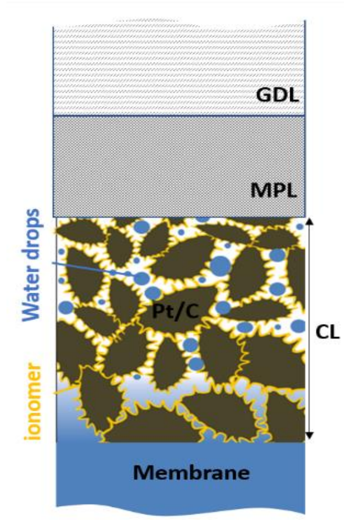
The performance of proton exchange membrane fuel cells (PEMFCs) is limited by mass transport in their gas diffusion electrodes, especially at intermediate and high current densities. Mass transport involves the passing of gases from the outside to the porous layers of the electrodes until the catalyst centers where electrochemical reactions take place. The porous layers, ie. the catalyst layer (CL), microporous layer (MPL), and gas diffusion layer (GDL), must have adequate morphology and hydrophobicity to favor these transport processes.

The CL is the layer where the reaction occurs which for a PEMFC cathode is $O_2 + 4H^+ + 4e^- \rightarrow 2H_2O$. Optimal behavior requires a high density of '*three-phases boundaries*', ie. areas where solid, liquid, and gas phases are close enough to accelerate the access of reactants and electrons to catalyst centers (Pt). The CL must also have low electronic and ionic resistances. Such bunch of conditions can only be accomplished with porous structures based on carbon, able to keep an appropriate gas and water contents ratio (saturation), having good ionomer phase distribution, and small interparticles distance. On the other hand, the GDL and MPL are porous transport layers for gases, water, and electrons, so their water saturation level should be kept as low as possible during fuel cell operation.

In this communication, the performance of PEMFCs is analyzed as a function of CLs morphological properties. CLs based on Pt, carbon, and ionomer phases, are prepared using different ink deposition methods, resulting in different morphology and distribution of components. Among deposition methods, the *electrospray* produces large superhydrophobic pores with a high catalyst (Pt/C) exposition, dendritic ionomer distribution over catalyst surface, and high porosity (see Figure). These properties allow for a high density of three-phase boundaries. Compared with layers prepared by spray, the cathodic electrosprayed CL improves PEMFC performance by 20 – 25% due to better mass transport properties[1]. Electrodes with different CL have been tested under different conditions and configuration, and their mass transport properties characterized using methods based on *transport impedance*[2].



Scheme of a superhydrophobic CL.

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References:

[1] J. J. Conde, P. Ferreira-Aparicio, and A. M. Chaparro, *ACS Appl. Energy Mater.*, **4**, 7394–7404 (2021).
[2] M. A. Folgado et al., in *Proceedings EFCF 2021 Low-Temperature Electrolysers, Fuel Cells & H2 Processing*,, vol. 0704, p. 225–230 (2021).