Novel porous layers and membranes for more efficient and durable PEM fuel cells

Saverio Latorrata

Materials for Energy and Environment Laboratory, Department of Chemistry, Materials and Chemical Engineering "Giulio Natta", Politecnico di Milano

Proton exchange membrane fuel cells (PEMFCs) are hydrogen-fed electrochemical devices constituted of a series of components contributing to generate electricity with high efficiency and limited pollutant emissions. The microporous layer (MPL) is one of the most recently introduced components; it is deposited on the gas diffusion layer (GDL) and improves dramatically performance and water management of the cell.

The talk will first illustrate advancements in new materials employed in MPLs, with a focus on polymers and carbonaceous materials intended as hydrophobic agent and conductive phase, respectively. Details will be provided about polymers other than the conventionally used PTFE aiming at reducing the diffusive limitations of the running fuel cell at high current density and the sintering temperature in the fabrication step. Various formulations based on new graphene nanoplatelets (GNPs) and carbon nanotubes (CNTs) mixed with common carbon black powders have been also developed. The blade-coating process will be described, and results of lab-scale tests in a running PEMFC will show how the different materials can affect the electrical performances and the durability of the microporous coatings in a view of better sustainability of the whole system. The durability has been assessed by performing accelerated stress tests (ASTs) to detect and mitigate the main degradation mechanism. Considering that a standardized protocol for MPLs still misses, ad-hoc ASTs have been designed and conducted, leading to the comprehension of a mechanical and erosion mechanism as the most demanding stress factor.

In addition, details on a more recent research line on novel electrolyte membranes will be provided. In particular, fluorine-free self-standing membranes based on polybenzimidazole (PBI) and graphene oxide (GO) are being developed in order to replace the well-known Nafion due to the possible future ban of materials potentially generating PFASs, and to the need to operate fuel cells at higher temperature, in the so called “conductivity gap”. As ion conductive species, GO-derived samples have been selected thanks to their oxygenated functional groups (carboxylic, hydroxyl, epoxy) and properly functionalized with sulfonic or phosphonic groups aiming at enhancing proton conduction. Composites with PBI have been developed to improve mechanical and thermal stability of the final membranes.