Recent Advances in Functional Materials for Ion-Exchange Membrane Fuel Cells (IEMFC)s: Proton- and Anion-Conducting Electrolytes, and Electrocatalysts for the Oxygen Reduction Reaction

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Fuel cells (FCs) are electrochemical energy conversion devices with an outstanding efficiency and that do not produce greenhouse gases. Hence, FCs are extremely attractive in the wake of today's massive efforts to decarbonize the energy sector at the global level to mitigate climate change.

Both the scientific community and industry devoted particular attention to FCs operating at low temperatures (T < 300°C) and mounting an ion-exchange polymeric membrane as the electrolyte separator. Such *"ion-exchange membrane fuel cells"* (IEMFCs) are highly compact, do not require extensive ancillaries and exhibit a high power density that is highly appealing for both stationary applications and the automotive sector.

The development of IEMFCs that are suitable for practical applications is a daunting challenge due to the difficulty to meet the necessary performance and durability figures at acceptable costs and without the risk to incur in supply bottlenecks of critical raw materials. This report overviews the contributions provided by the research group *"Chemistry of the Materials for the Metamorphosis and Storage of electrochemical Energy – CheMaMSE"* to advance the state of the art of functional materials for application in IEMFCs.

Proton-conducting electrolytes for application in polymer electrolyte membrane fuel cells (PEMFCs) and high-temperature proton-exchange membrane fuel cells (HT-PEMFCs) are covered, together with anion-conducting electrolytes for anion-exchange membrane fuel cells (AEMFCs). Electrocatalysts for the oxygen reduction reaction (ORR), one of the major bottlenecks in the operation of IEMFCs, are presented as well.

The interplay between the synthetic parameters, the physicochemical properties, the electrical response and the electrochemical performance of the various families of functional materials is elucidated in detail. The potential for applications is explored by the fabrication of prototype IEMFCs, that are tested in operating conditions.