Looking into fuel cells with neutrons

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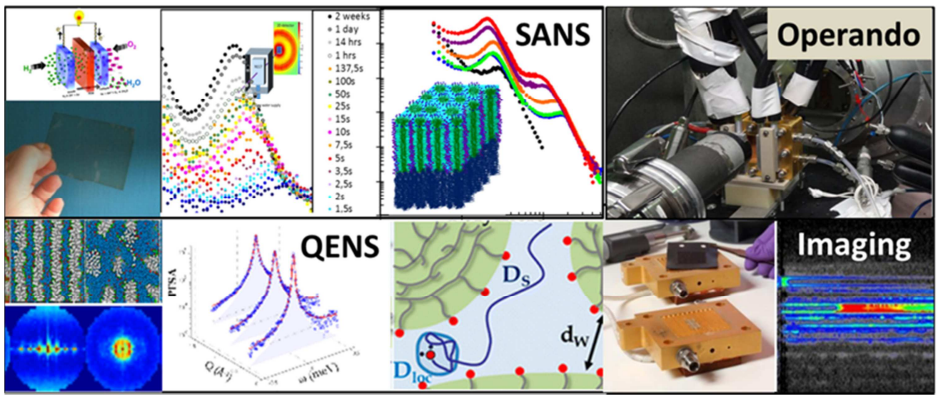
Proton exchange membrane fuel cells (PEMFCs) are promising electrochemical converters powering small portable devices and electric vehicles. The PEMFC produces electricity, heat and water and is considered as a key element for the future green energy. A PEMFC is based on a membrane–electrode assembly (MEA) that separates the hydrogen-filled anodic compartment from the air-filled cathodic compartment. The proton exchange membrane acts as a support for the electrode, physical barrier between H_2 and O_2 reactants, electronic insulator and proton conductor. State-of-the art materials are Perfluorinated Sulfonic acids (PFSAs) as Nafion. Alternative hydrocarbon-based compounds are also considered to overcome the PFSAs drawbacks (e.g. high cost and degraded performances at low relative humidities and high temperatures). PEMs are phase-separated nanostructured materials. A network of interconnected nanoscale ionic domains is formed upon hydration. The transport of protons within the hydrophilic phase is mediated by the water molecules and highly dependent on the topology and connectivity of the hydrated nanostructures. In-depth characterization of the structure-transport interplay is foreseen to establish the impact of chemical architecture and materials processing on the overall performance of the membrane.



In this context, neutron scattering techniques, including Small Angle (SANS), Quasielastic (QENS) and imaging techniques, are tools of choice. Herein, we will present an overview of insights gained into the structure and the dynamics of fuel cell membranes using neutrons, with particular focus on the elucidation of basic mechanisms (sorption, swelling laws, water diffusion, ion transport). The operando investigation of fuel cells will also be presented. The complementarity between neutrons and other experimental (SAXS, synchtrotron Infra-red, NMR) and numerical (Molecular Dynamics) techniques will be emphasized.