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Multiple Length Scales Hydration in Polymer Membranes for Fuel Cells

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The polymeric materials used in fuel cells applications either as proton (PEMFC) or anion (AEMFC) exchange membranes are characterized by a nanoscale phase separation into hydrophilic domains and hydrophobic crystalline regions, which enables a high conductivity and provides a good chemical and mechanical stability of the membrane. Owing to its high proton conductivity and chemical stability, Nafion was established as benchmark for PEMFC applications. However, due to its high cost and limitations in operating conditions, there is an intense search for low-cost alternative materials with similar conductive and chemo-mechanical properties. On the other hand, the high proton conductivity in PEMFC is achieved in acidic environment that requires the consumption of acidic-resistant precious metal catalysts and impedes a wide-scale commercialization. As alternative technology, the AEMFC use inexpensive, non-noble metal catalysts. However, the AEM conductivity and long-term durability is still lower compared to the PEM, therefore the interest in finding new high-performance materials. The conductivity in polymer electrolyte membranes depends on the water behavior inside the polymer network across the full range of length scales in the membrane. As we will present here, small-angle neutron scattering with contrast variation used at MLZ is a powerful technique for unraveling the hierarchical morphology and understanding the structure–property relationships in such polymeric membranes.

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