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Ion dynamics in soft electrolytes for fuel cells and batteries

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Energy conversion and storage devices as fuel cells or lithium-ion batteries contain an electrolyte to transport ions from the negative to the positive electrode. This electrolyte can be a salt-containing liquid as in state-of-the art Li-ion batteries, a polymer as in proton exchange membrane fuel cells and solid-state batteries, or inorganic conductors as oxides or glass ceramics. In all cases, understanding the relation between elementary diffusion mechanisms, as well as their dependence on solvent content, molecular architecture, structure, temperature, materials fabrication process and integration into real systems, is key and requires characterization of the ion dynamics at multiple scales. Typically, the performance of an electrolyte is determined in terms of macroscopic ion conductivity, but microscopic-scale information is needed to establish the driving forces and limiting factors, in view of optimizing materials design. In this talk we will show examples of multi-resolution QENS studies performed on different types of soft electrolytes (ionomers, membranes, ionic liquids) to identify the nature of motions as well as their characteristics (relaxation times, diffusion coefficients, jump distances, activation energies). We will also highlight the need for complementary tools e.g. NMR and molecular dynamics simulation to provide a mechanistic understanding of the interplay between ion conduction and the matrix / polymer / solvent motions, and provide the full multi-scale picture of ion dynamics in complex soft ionic systems.

References

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Primary authors: LYONNARD, Sandrine (UGA, CEA, CNRS, IRIG, SyMMES, F-38000 Grenoble); BERROD, Quentin (UGA, CEA, CNRS, IRIG, SyMMES, F-38000 Grenoble)

Presenters: LYONNARD, Sandrine (UGA, CEA, CNRS, IRIG, SyMMES, F-38000 Grenoble); BERROD, Quentin (UGA, CEA, CNRS, IRIG, SyMMES, F-38000 Grenoble)

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