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Why the new generation electrolytes are independently moving towards nanostructuration

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Cobalt-free cathodes, post-Lithium carriers, metal-based anodes, and ionic liquid electrolytes are a few topics tackled in recent years to improve battery technologies. While all of them could (and will) be improved over time, electrolytes are prominent because of their ease of adapting to current technologies. Conventional organic electrolytes are usually flammable, toxic, and harmful to humans and the environment. For these reasons, over the years, several alternatives have been proposed. Ionic Liquids[1] are promising from a safety point of view, being non-volatile and non-flammable, but they are usually fluorinated to meet specific performance standards. Another sustainable and cost-efficient approach is represented by the Water-in-salt electrolytes (WiSEs)[2,3], given that the used salt is sustainable itself. Finally, the newest approach is to tackle the solubility properties of salts to obtain locally concentrated electrolytes using non-solvating solvents[4]. For all of the proposed new technologies, their impressive properties seem to emerge from the peculiar structural organizations of the species in the system. Therefore, employing experimental (SAXS and Raman) and computational (MD and DFT) techniques to comprehensively understand how the chemical species interact in such systems, is mandatory to further progress in the research.

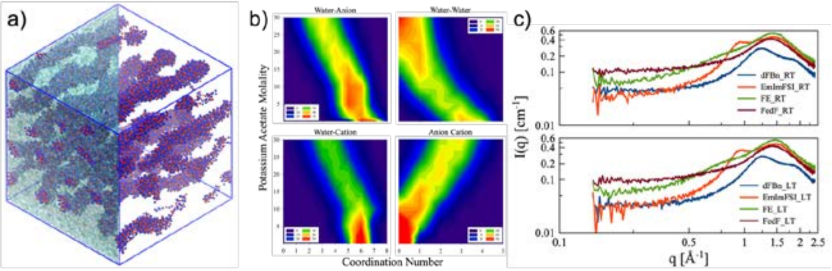

Figure 1: a) Snapshot of the simulation box of a Locally Concentrated electrolyte. The ionic liquid comprise the worm-like structures, the solvent is only depicted on the left side as a transparent medium. b) coordination numbers as a function of salt concentration in a Water-in-salt electrolyte. c) X-ray scattering patterns for ionic liquid electrolytes and locally concentrated ionic liquid electrolytes at two different temperatures (20 °C top, and -20 °C bottom).

References:

[1] J. S. Wilkes, A short history of ionic liquids—from molten salts to neoteric solvents, Green Chemistry, 2002, 4, 73–80.
[2] L. Suo, F. Han, X. Fan, H. Liu, K. Xu and C. Wang, 'water-in-Salt' electrolytes enable green and safe Li-ion batteries for large scale electric energy storage applications, J Mater Chem A Mater, 2016, 4, 6639–6644.
[3] J. Han, A. Mariani, S. Passerini and A. Varzi, Energy Environ Sci, 2023.
[4] X. Liu, A. Mariani, H. Adenusi and S. Passerini, Angewandte Chemie - International Edition, 2023.