Eliminating the ionic liquid from hybrid solid state electrolytes

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Solid state electrolytes can enhance Lithium-ion (Li-ion) batteries significantly due to improved cycling performance and increased safety. In the past, several solid state electrolytes have been successfully developed, such as LISICON, garnets, etc. [1] These examples, however, suffer from very low ionic conductivity ($<10^{-4}$ S/cm) when compared to contemporary liquid electrolytes ($>10^{-3}$S/cm). Reducing the interfacial resistance between electrodes and solid state electrolyte is another challenge. The use of hybrid solid state electrolytes can offer an answer to these issues.

Hybrid solid state electrolytes consist of a solid matrix and an impregnated ionic liquid electrolyte. [2,3] Typically the latter is formed by dissolving a Li-salt (e.g. LiTFSI, $LiPF_6$, …) in an ionic liquid, which acts as a solvent, similar to carbonates in conventional liquid electrolytes. Hence a high ionic conductivity and an intimate electrolyte/electrode interface can be achieved. However, these ionic liquids are very costly, which hinders implementation in battery technology.

In this research, a costly ionic liquid is not used. Here, it is the Li-salt itself which is crucial in forming the Li^+ conductive liquid phase (at room temperature). The hybrid electrolyte under study is synthesized in a facile one-pot non-aqueous sol-gel route at room temperature. Impedance spectroscopy reveals a high ionic conductivity of up to 1.15 mS/cm at room temperature and a beneficial anodic electrochemically stability limit of 4.5 vs. Li^+/Li is found via cyclic voltammetry (CV) and linear sweep voltammetry (LSV). Hybrid solid state electrolyte membranes are made and used in the assembly of $LiFePO_4$ (LFP) half cells. These cells display good reversibility and high experimental capacities for over 150 cycles (at 0.2C, 16°C). Hence the hybrid solid electrolyte at hand is promising for implementation in Li-ion battery technology.

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