Ionic Liquid-based Electrolytes for High-Energy Batteries

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Room temperature ionic liquids (ILs), i.e., salts which are molten at room temperature, represent a very interesting class of room-temperature fluids. Their physicochemical properties can be finely tuned (through even slight modification of the IL structure and/or introduction of functional groups) to match particular operating conditions. As such they have been proposed as media for the synthesis of electrochemical storage [1] and conversion materials [2]. With regards to their use as electrolyte components in Li- [3] and Na- [4] batteries, IL-based electrolytes offer improved safety [5] in terms of flammability [6] even stabilizing the de-lithiated cathode [7]. In particular, the long-term cycling performance of lithium-based cells is significantly improved both in Li-ion [8] as well Li-metal [9] configuration.

Although affected by the high viscosity drawback, different approaches appear to be very promising to enhance the room temperature conductivity of IL-based electrolytes. Among them, the approach involving IL mixtures show improved properties, often not exhibited by single ionic liquid materials [10]. Mixture of ILs, incorporating the lithium salt and small amounts of SEI forming additives, have been demonstrated succesful electrolytes for Si and Ge electrodes in LIBs [10] as well as the hard carbon electrode in the novel Na-seawater cells [11].

A second approach involves the use of the high lithium concentration in combionation with proper ILs. In spite an order of magnitude difference in the conductivity and viscosity, this high concentration electrolyte outperforms the lithium-dilute electrolyte with the same components in terms of rate capability in Li metal/LFP cells and LTO/LFP cells [12].
Lab-scale prototypes using different IL-based electrolytes can easily achieve 2000 cycles with no obvious sign of capacity decay, even in case of overcharge/over-discharge, at elevated temperatures or with higher mass loadings.

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