

Water as an Effective Additive for High-Energy-Density Na Metal Batteries? Studies in a Superconcentrated Ionic Liquid Electrolyte

Shammi A. Ferdousi, Dr. Matthias Hilder, Dr. Andrew Basile, Dr. Haijin Zhu, Dr. Luke A. O'Dell, Dr. Damien Saurel, Prof. Teofilo Rojo, Prof. Michel Armand, Prof. Maria Forsyth, Prof. Patrick C. Howlett✉

First published: 10 February 2019 | <https://doi.org/10.1002/cssc.201802988>

- [a] Shammi A. Ferdousi, Matthias Hilder, Andrew Basile, Haijin Zhu, Luke A. O'Dell, Michel Armand, Maria Forsyth, Patrick C. Howlett*,
 Surname(s) of Author(s) including Corresponding Author(s)
 Institute for Frontier Materials (IFM), Deakin University
 Burwood, Victoria 3125, Australia
 E-mail: patrick.howlett@deakin.edu.au
- [b] Damien Saurel, Teofilo Rojo, Michel Armand
 CIC Energigune, Alava Technology Park
 Albert Einstein 48, 01510 Miñano Alava, Spain

Abstract

The effect of water on the properties of superconcentrated sodium salt solutions in ionic liquids (ILs) was investigated to design electrolytes for sodium battery applications with water as an additive. Water was added to a 50 mol % solution of NaFSI [FSI=bis(fluorosulfonyl)imide] in the ionic liquid *N*-methyl-*N*-propylpyrrolidinium bis(fluorosulfonyl)imide (C₃mpyrFSI). Although the thermal properties (e.g., glass transition temperature) showed little dependence on the water content, the viscosity and, in particular, the ionic conductivity were strongly affected. The Na|Na symmetrical cell cycling performance was strongly dependent on the applied current density as well as on the water content. At higher current densities (1.0 mA cm⁻²) the polarization profiles showed a water dependence, suggesting that water was actively involved in the formation of an improved solid electrolyte interface layer (SEI) for high-water-content samples (1000–5000 ppm), resulting in improved long-term cycling stability. The initial impedance of cells cycled at 1.0 mA cm⁻² (measured after 20 cycles) was elevated after water addition, and large polarizations occurred for the “wet” samples. However, with further cycling the wet cells began to exhibit lower polarization and improved stability compared to the “dry” sample. The Na|NaFePO₄ cell cycling performance was also demonstrated with minimal effect on the cell capacity, further highlighting the negligible activity of water in these electrolyte systems. In fact, reduced cell polarization and a more clearly defined charge profile were evident after water addition. The work shown here suggests that water may be used as a convenient and inexpensive additive for superconcentrated sodium IL electrolytes for improved device performance.