Polymer Gel Electrolytes based on Ionic Liquids for Li-Ion-Batteries

Andreas Hofmann*, Martin Tosoni*, Michael Schulz*, **, Thomas Hanemann*, **

* Karlsruher Institut für Technologie, Institut für Angewandte Materialien - Werkstoffprozesstechnik, Karlsruhe, Germany
** Universität Freiburg, Lehrstuhl für Werkstoffprozesstechnik, Institut für Mikrosystemtechnik (IMTEK), Freiburg, Germany

Summary
- Interaction of ionic liquid based electrolytes with graphite electrodes
- Improvement of the Li-ion battery performance with gel polymer electrolytes
- Li⁺ conductivity, safety, cycle stability

Motivation
- Intrinsically safe Li-ion battery electrolytes are not available
- Combination of ionic liquids and gel polymer electrolytes for new feasible gel polymer electrolytes: incombustible and leak proof
- Increase of the Li-ion mobility by the use of organic carbonates
- Functionality of Li-ion batteries:

Li-Ion Cell
- Negative graphite electrode
- Positive NMC electrode
- Conducting salt: LiTFSA*
- Gel features:
  - highly elastic, temperature stable
  - gel as separator
  - accurate ion mobility
- PVdF-HFP based gel electrolyte

Ionic Liquids in PVdF-HFP gel electrolytes

Organic carbonates in IL-PVdF-HFP gels, Li|C half cells

- Ligil polymer electrolyte/C - cells without a separator
- Current: C/20 → full charge and discharge in 20 hours
- Interracalation of propylene carbonate (PC) and N-methyl-N-propylpyrrolydinium (MPPyrr) into the graphite layer
- Synergetic effect of PVdF-HFP + MPPyrr-TFSA + PC at the graphite-electrolyte interface enables lithium intercalation
- Successful cycling of the LiC - half cell without any additive!

NMC|gel|C - cell performance

- Cell with 25 wt.-% vinylene carbonate (VC) not working
- Continuous decrease of the specific capacity without the addition of VC
- High reversibility of the specific capacity with EC and VC in the gel matrix

Conclusions
- Ionic liquids can successfully be applied in PVdF-HFP gel polymer electrolytes
- Best results for the ionic liquid N-methyl-N-propylpyrrolydinium bis(trifluoromethylsulfonyl)azanide
- SEI effect on graphite electrodes based on a synergetic effect of PVdF-HFP, MPPyrr-TFSA, Li-TFSA, and PC
- Successful realization of Li-ion-polymer cells with a cell configuration of [LiNi0.3Co0.3Mn0.3]O2|gel polymer electrolyte|C

Acknowledgements

This work was supported by the BMBF within the program of LIB-2015 and the Karlsruhe Institute of Technology. We acknowledge IoLiTec Ionic Liquids Technologies GmbH and Evonik Litarion GmbH for kindly providing chemicals and electrode materials.