Ion transport mechanism of salt-doped single-ion conducting polymer electrolytes

Open: Now (October 2020)

Aim/Purpose: Reveal the ion transport mechanism of single-ion conducting (SIC) polymer electrolytes upon Li-salt doping. The overall purpose is to enable safer lithium batteries.

Background: Solid polymer electrolytes (SPEs) are usually made by simply doping a polymer matrix with a Li-salt and are of large interest for lithium battery technologies due to their improved safety, mechanical stability, and flexibility. Yet, their low ionic conductivity at room temperature and the concentrations gradients created due to the different mobilities of the Li-salt anions and cations remains a challenge.[1] One special SPE design to remedy the latter is to graft the anion onto the polymer backbone, forming a SIC, whereby the Li^+ cation becomes the sole mobile species. However, the ionic conductivities most often remain too low, due to the rigidity of the polymer matrix. Li-salt doping of the SIC LiPSTFSI is expected to impact on the ionic conductivity and the ion transport mechanism by increasing both the number of Li^+ available and the flexibility of the polymer matrix. In general, ion transport follows either an Arrhenius (by ion hopping) or a Vogel-Tammann-Fulcher (VTF) (limited by polymer segmental motion) behavior. The main research question is whether the Li-salt addition enhances one (or both) ion transport mechanisms and subsequently if/how this can be used to tailor the ionic conductivity without compromising other SPE/SIC properties.[2,3]

Project plan: Prepare a set of SPEs based on the SIC LiPSTFSI and the LiTFSI salt as dopant. Characterize the resulting electrolytes by both impedance and dielectric spectroscopy to obtain the ionic conductivity with special attention given to different cell configurations and temperature dependence. Finally, analyze and reveal the ion transport mechanism.

Time-plan: *ca.* 20 weeks. Week 1-5: Literature on batteries, SPEs, SICs, ionic conductivity. Week 3-6: SPE preparation. Week 4-17: Impedance and dielectric spectroscopy measurements and data analysis. Week 14-20: Write the MSc thesis and prepare for the presentation.

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1. Zhang, H. *et al.* Single lithium-ion conducting solid polymer electrolytes: Advances and perspectives. *Chem. Soc. Rev.* **46**, 797–815 (2017).
2. Seki, S. *et al.* Distinct difference in ionic transport behavior in polymer electrolytes depending on the matrix polymers and incorporated salts. *J. Phys. Chem. B* **109**, 3886–3892 (2005).
3. Martinez-Ibañez, M. *et al.* Unprecedented Improvement of Single Li-Ion Conductive Solid Polymer Electrolyte Through Salt Additive. *Adv. Funct. Mater.* **2000455**, (2020).

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