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In situ small angle X-ray scattering investigation of solid-state polymer electrolyte for lithium-ion batteries

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Many present problems regarding the safety of liquid electrolytes in lithium-ion batteries may potentially be overcome by the use of solid-state polymer electrolytes. Polystyrene-block-polyethylene oxide PS-b-PEO diblock copolymer (DBC) electrolyte have been recently investigated as a membrane for Li-ion battery. The performance of these DBC electrolytes strongly depends on its morphology, serving highly oriented PEO domains as pathways for lithium ions migration. Thus, in situ structural investigation of these Li-ion doped DBCs systems during cycling in an operating battery is essential, which can be done by neutron or X-ray small angle scattering. In situ small angle neutron scattering on a working pouch cell has been performed, which proved the structural stability of the polymer electrolyte. Also, capillary-based micro-battery cell allowing simultaneous electro-chemical and structural evaluation by X-ray scattering has previously been reported [1].
Figure 1: Schematic of the in situ SAXS setup.
Figures 2 and 3 show 1d radial averages of the SAXS data acquired while cycling the battery for LFP/C (2) and LFP/Li (3) cells. While the system with the graphite anode shows a stable structure over big number of cycles, the LFP/Li system is less structured from the beginning of the measurements and loses the remaining ordering over cycling. The influence of the lithium metal on the polymer electrolyte and the interface between the two layers will be further investigated in this work in order to determine the applicability of lithium metal anodes.
[1] R.E. Johnsen, P. Norby, J. Appl. Cryst. (2013), 46, 1537.
[2] R. Bouchet, S. Maria, R. Meziane et al., Nature materials (2013), 12, 452-7
The current in situ small-angle X-ray scattering (SAXS) study of the solid-state polymer electrolytes using a modified version of the micro-battery cell provides a deeper insight into the structural modification. Figure 1 shows the currently used setup used for the X-ray experiments. A battery cell is assembled inside a glass housing, consisting of a flat capillary tube. Lithium iron phosphate (LFP) and lithium/graphite (Li/C) are used as cathode and anode active materials for this system. Composite electrodes as well as the polymer electrolytes are prepared by solution casting onto copper current collectors [2].
Figures 2 and 3: 1d radial averages of the SAXS data acquired during the cycling of a LPF/C (left) LFP/Li cell (right).

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