Investigation of rechargeable lithium-sulfur batteries by in-situ techniques

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Lithium-sulfur battery

Electrode compositions:
- Sulfur (50 wt. %)
- Carbon black (40 wt. %)
- PVDF (10 wt. %)

Electrolyte:
1 M LiPF6/TEGDME

Separator: Celgard 2500

Anode:
Lithium

Electrochemical reactions:

\[
\text{Discharge:} \quad \text{Li} + \text{S}_{8(s)} \rightarrow \text{Li}^+ + \text{e}^- + \frac{1}{2} \text{S}_8^{2-}
\]

\[
\frac{1}{2} \text{S}_8^{2-} + \text{e}^- \rightarrow \frac{1}{2} \text{S}_8
\]

\[
\frac{3}{2} \text{S}_8^{2-} + \text{e}^- \rightarrow \text{S}_6
\]

\[
\frac{1}{2} \text{S}_2 + \text{e}^- \rightarrow \frac{1}{2} \text{S}_2
\]

\[
2 \text{Li}^+ + \text{S}^{2-} \rightarrow \text{Li}_2\text{S}(s)
\]

Materials and methods

In-situ XRD cell

Swagelok-cell

EIS

- Potentiostatic: 5 mV amplitude
- Equidistant intervals of 50 mC
- Frequency range: 1 MHz to 60 mHz

End Voltages (V): 2.8/1.5

Discharge current: 300 A kg\text{Sulfur}^{-1}

Results

Variation of the equivalent circuit elements during cycling determined by EIS analysis.

- The highest electrolyte resistance, related to the highest concentration of polysulfides is detected at the end of the first discharge and charge plateau (43 % DOD and 56 % DOC).
- The impedance contributions associated to the processes in the cell are strongly dependent on the depth of discharge and charge of the cell [2].

AFM topography and current images of cathodes

- At discharge rate of 300 A kg\text{Sulfur}^{-1} sulfur reduces consecutively during the first discharge to Li$_2$S.
- The formation of Li$_2$S was observed for the first time at a depth of discharge of 60 % in the second discharge plateau at 1.8 V.
- During the charge cycle, Li$_2$S reacts entirely and sulfur recrystallizes with a different orientated structure and smaller particle size [1].

References


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