German Aerospace Center (DLR)

Institute of Engineering Thermodynamics

Temperature Influence on the Solid Electrolyte Interphase in Lithium-Ion Batteries

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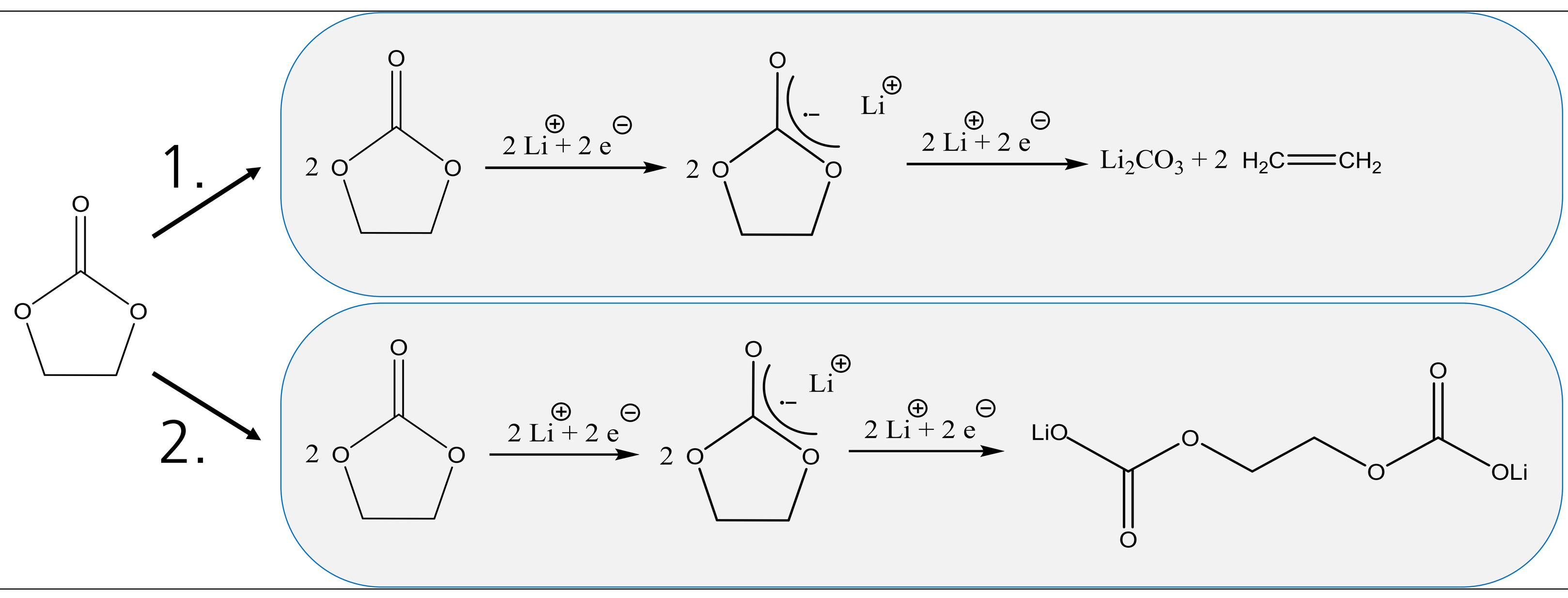
Introduction

Solid Electrolyte Interphase

- Forms in the 1st cycle
- Prevents delamination of the anode by cointercalation of solvent molecules
- Causes irrevesible capacity loss

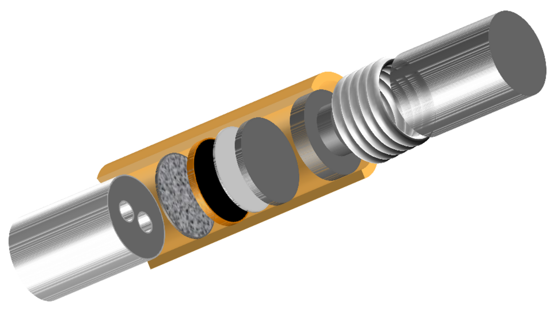


Influential factors

- Anode material and morphology
- Electrolyte solvents
- Conducting salt
- Electrolyte additives
- **Temperature**

Principle of Application

Cell Construction

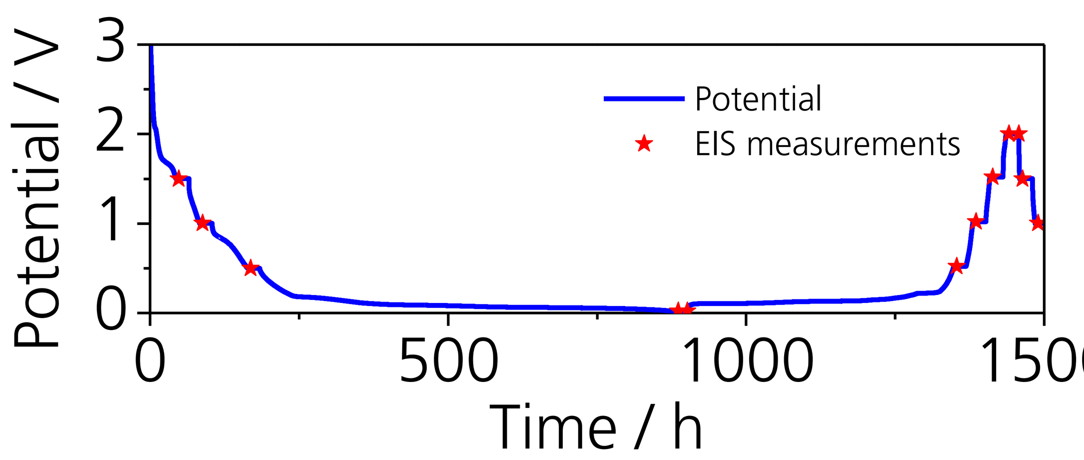


- Lithium vs. Graphite
- Electrolyte: 1 M $LiPF_6$ in EC:DEC 3:7 wt%
- Assembly under argon atmosphere with O_2- and H_2O-contents < 1 ppm

Cyclovoltammetry

- Triangular voltage with slope = 0.5 mV/s
- Cut-off voltages: 0.02 V and 1.5 V
- Resulting current curve reveals information about electrode processes

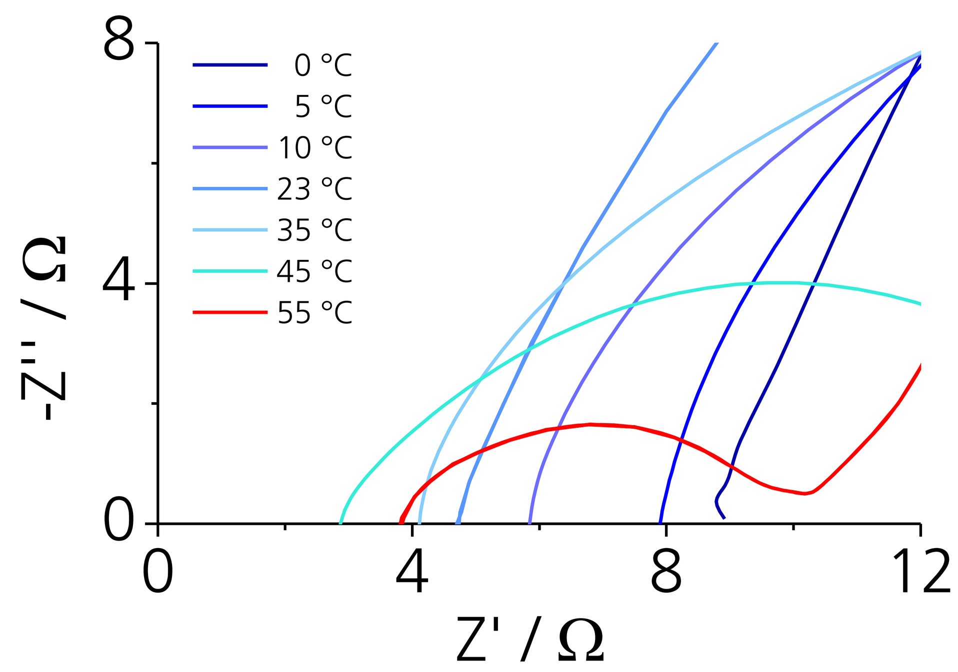
Electrochemical Impedance Spectroscopy

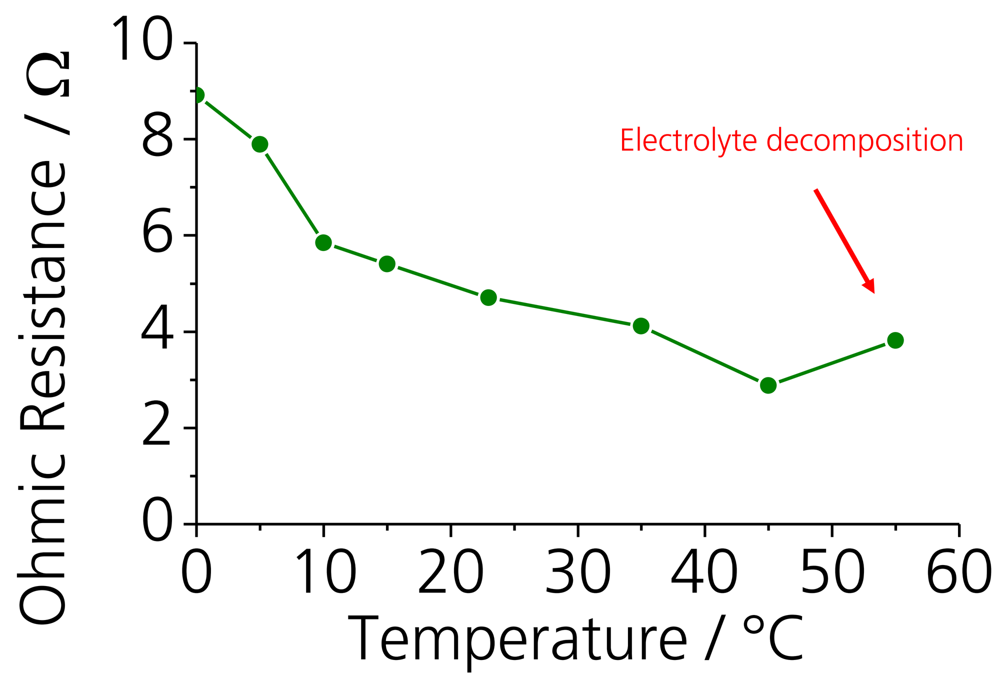


- C-rate: 1C
- EIS measurements every 0.5 V
- Relaxation time: 5 minutes
- Frequency range: 10 mHz – 4 MHz
- Excitation: potentiostatic with û=5 mV

Experimental Results

Electrochemical Impedance Spectroscopy

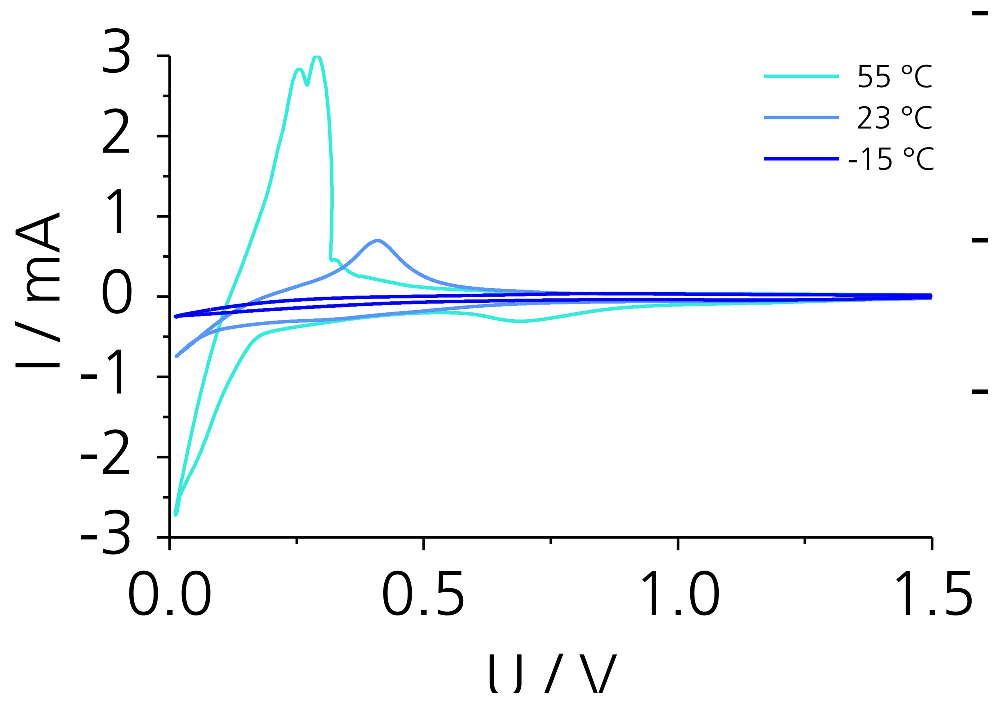




- EIS shows that the ohmic restistance decreases with rising temperature
- At 55 °C the ohmic resistance increases due to electrolyte decomposition

→ Temperatures above 55 °C should be avoided during SEI formation

Cyclic Voltammograms



- Electrolyte decomposition at 55 °C
- Two possible decomposition reactions for EC depending amongst others on temperature
- Single-electron reduction takes place at 0.8 V and mainly leads to Li_2CO_3
- Double-electron reaction takes place at 0.5 V – 0.8 V and leads to different alkylcarbonates

- The two decomposition reactions compete with each other
- The SEI formed by the single-electron reduction is less stable and leads to more gaseous products[1]
- With increasing temperature the single-electron reduction is dominant

Conclusions

- Temperatures above 55 °C should be avoided as they lead to electrolyte decomposition
- Two reduction reactions of EC compete; they lead to differences in SEI stability
- At elevated temperatures the double-electron reduction is dominant, which leads to less stable SEI layers and more gaseous products

References

[1] S. S. Zhang, J. Power Sources 162 (2006) 1379.

Li-EcoSafe

FKZ:03X4636A

Knowledge for Tomorrow

Wissen für Morgen

DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center

PtJ Projektträger Jülich Forschungszentrum Jülich

GEFÖRDERT VOM Bundesministerium für Bildung und Forschung