PAUL SCHERRER INSTITUT

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ELECTROCHEMISTRY LABORATORY

# Pitfalls in Li−S Rate Capability Tests

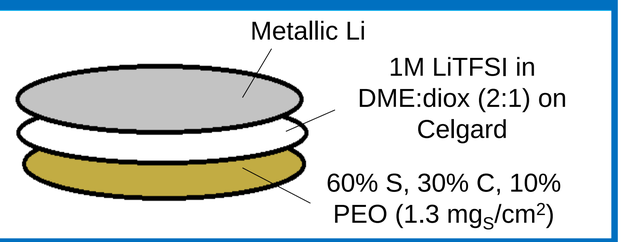
Tiphaine Poux, Petr Novák, and Sigita Trabesinger

*Paul Scherrer Institut, Electrochemistry Laboratory, CH-5232 Villigen PSI, Switzerland*

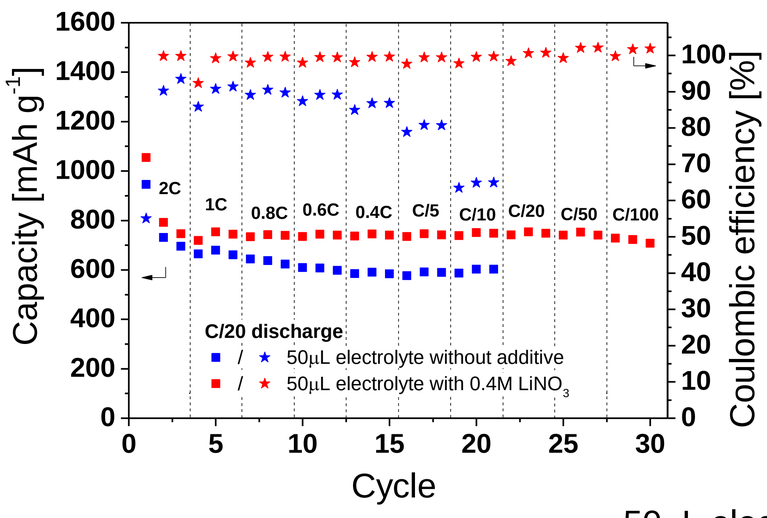
*tiphaine.poux@psi.ch*

## Background of the Study

- Rate-capability tests are widely used to highlight advances in Li–S-system development, and many effects of various experimental parameters are often neglected.
- Here we present the **individual effects** of a number of cycling- and electrolyte-related parameters on the rate performance of a **simple Li–S cell**.

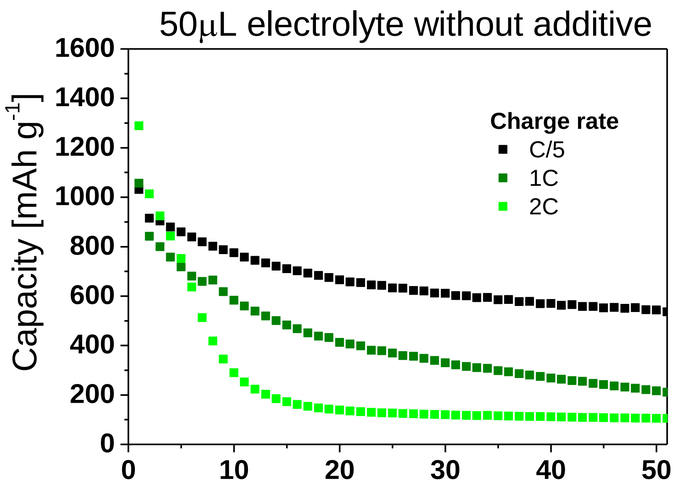



## Effect of Charge Rate

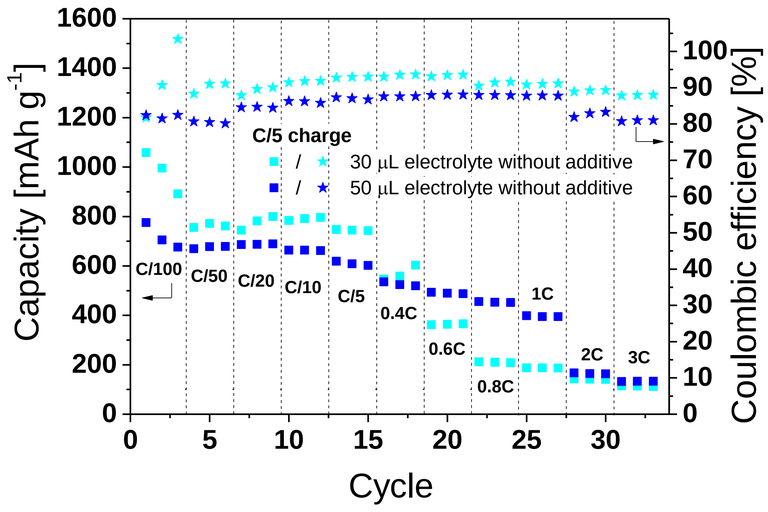



- Little impact of **charge rate** on delivered capacity
- **Polysulfide shuttle** at low charge rates – impossible to charge without additive

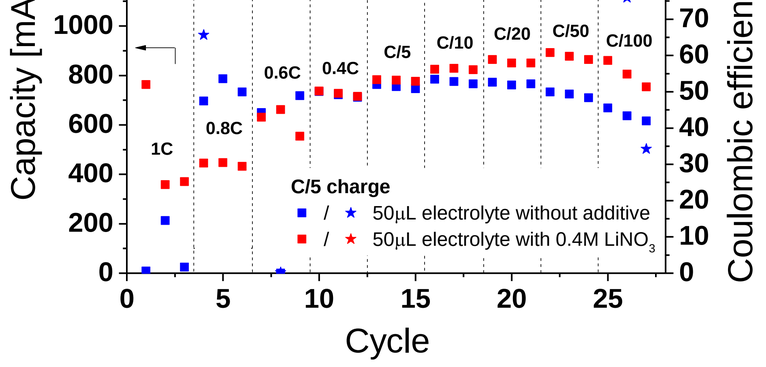
- Cell failure during long-term cycling due to large **charge overpotentials** at higher charge rates



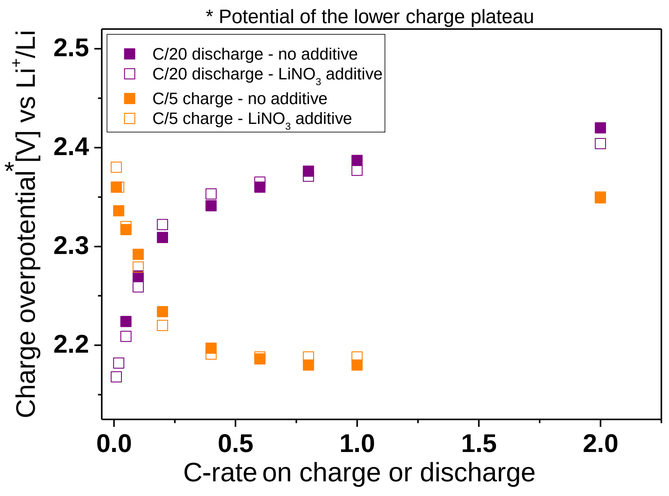

## Effect of Discharge Rate

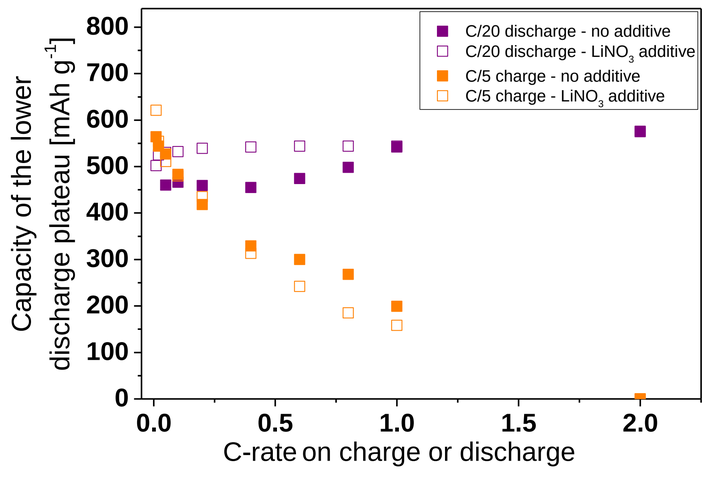



- Strong impact of **discharge rate** on delivered capacity
- Loss of active material
  - with **low rates** in the first cycles
  - with an **excess of electrolyte**
- Insufficient **sulfur utilization** at high rates due to limited electrolyte availability



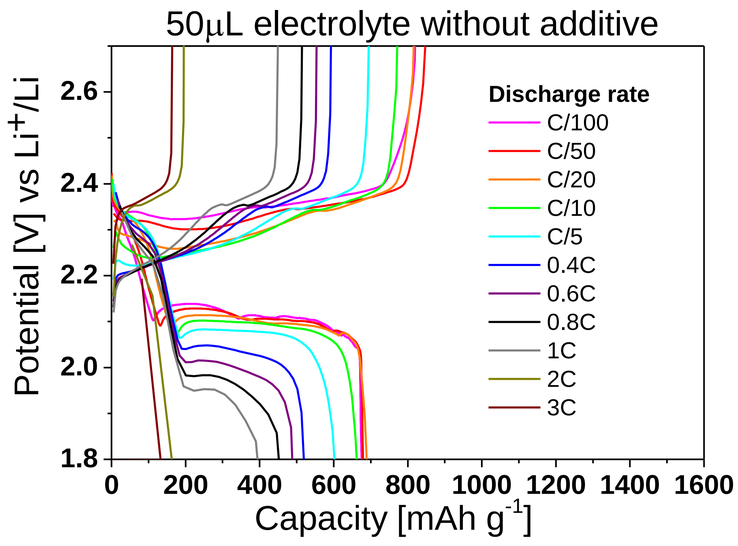

## Dependency of Charge Overpotential




- Effect of both **state of discharge** and **charge rate** on charge overpotential due to slow $Li_2S$ oxidation

- Importance of **cut-off potential** choice with large discharge overpotentials at high discharge rates




## Conclusions

- **The rate-capability results of a Li–S cell are sensitive not only on the cycling rate but also on the cycling prehistory of the cell** — if the applied cycling protocol is based on increasing or decreasing rates and if varying rates are applied on charge, discharge or entire cycle. This should be taken into account in Li-S modelling.
- Beyond electrode and cell parameters, **a standardization of the rate-capability-test protocols is required for a meaningful comparison of different Li–S systems**.
- **Only long-term cycling proves the rate capability of a Li–S cell.**

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