

An Identifiability Study of Lithium-Ion Battery Capacity Fade Using an Electrode-Specific Cell OCV Model

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Abstract

To achieve more accurate aging diagnosis and more effective management of lithium-ion batteries, it is essential to distinguish among the symptoms caused by different degradation mechanisms and be able to model them. So far, a lot of work has been focused on building mechanistic aging models for certain parameters of a cell model, but thorough examination of the extent to which these parameters can affect the detailed voltage response, and in turn be identified from such measurements, is scarce in literature. Moreover, capacity fade and power fade are often entangled in existing studies using a finite-current discharging/charging setup.

As an initial step to unravel such intricate parametric influences and identifiability, we adopt a cell OCV (open circuit voltage) model and ignore polarization due to kinetic effects to focus on degradation manifested in the full-cell OCV curve and total capacity only. This cell OCV model, which is adapted from [1], is parametrized by two electrode OCP (open circuit potential) curves and three independent parameters: the cyclable lithium inventory, and the amount of anode and cathode active materials, all of which are directly related to capacity fade. We visualize and quantify the different impacts of LLI (loss of lithium inventory) and LAM (loss of active materials) on different segments of the cell OCV curve and on total capacity using gradients and Fisher information. Moreover, we use mutual information in a Bayesian setup to identify the amount and kind of measurements required to identify these parameters given a priori knowledge of them. Along the way, we also clarify the differences between electrode SOC (state of charge) and electrode lithium stoichiometry, and their implications for using electrode OCP and determining electrode capacity, which can at times cause confusion.

Finally, we demonstrate how some of the degradation patterns outlined in [2], [3] can be cast among the continuum of capacity fade scenarios characterized by this simple cell OCV model. In particular, we show how incorporating electrode coulombic efficiencies into the model unifies and simplifies existing results about accounting for side reaction effects on cyclable lithium inventory [3]–[5].

References

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