A Parametric Study of Lithium-Ion Battery Capacity Fade Using a 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 mechanisms of capacity fade and be able to model them. In literature, a lot of focus has been on building mechanistic aging models for certain parameters of a cell model, but it lacks a thorough examination of how these parameters affect voltage response in the first place. Moreover, thermodynamic and kinetic pathways of such effects are usually entangled in finite-current discharging/charging. As an initial step to unravel such intricate parametric influences on capacity fade, in this study, we adopt a cell OCV model parametrized by the electrode OCVs, the total lithium inventory, and the amount of anode and cathode active materials, and we detail the impacts of loss of lithium inventory and loss of active materials on the cell OCV curve and on capacity. We demonstrate how some of the common degradation patterns can be exemplified by this simple cell OCV model and differentiate the thermodynamic and kinetic pathways that lead to capacity fade. Along the way, we also clarify the differences between full cell SOC, electrode SOC, and electrode Li stoichiometry, as well as how full cell OCVs are linked to electrode OCVs, which can easily cause confusion in literature.

Keywords: Lithium-ion battery, capacity fade, cell OCV, parametric study.