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Miss. Belfun Arslan

Belfun Arslan^{1,2}, Cem Hakan Yilmaz²

¹Gebze Technical University, Kocaeli, Turkey

²Mutlu Battery, Istanbul, Turkey

Identification of capacity increase mechanism during early cycle of Li-ion batteries by Electrochemical impedance spectroscopy

Lithium-ion (Li-ion) batteries have been widely used in electric vehicles (EVs) due to their high energy density, low self-discharge, and long lifetimes. For the reliable and safe operation of lithium-ion batteries, accurate capacity estimation is essential. Machine learning methods are employed to estimate the battery capacity. However, the increase in capacity, which is observed in the early cycles of the Li-ion battery, can cause the algorithm and battery system to operate unstable. In this study, the underlying mechanisms of battery capacity increase during the early charge/discharge cycles with electrochemical impedance spectroscopy (EIS) are discussed using the 3RCPE circuit. The study was carried out on six NMC-polymer batteries at room temperature under different depth of discharge (20 and 60 DOD) and current conditions (0.5C and 1C). To compare batteries under different profiles, loss of conductivity (CL), active material (LAM), and lithium inventory (LLI) are analyzed in a quantitative manner. EIS results indicate that for all cells that exhibit recovery for CL, LAM and LLI in early cycles, the impedance decreases dominantly due to the improvement of current collector and electrode contact resistance (CL) and thus confirm the passive electrode theory. Also, the highest capacity increase with % 2.4 is achieved with lowest C-rate and highest DOD. However, for the following cycles, aging is faster at high DOD than low DOD at the same current rates. The study examines how the operating conditions affect the profile of the cell's capacity rise throughout the early cycle. The results help determine Li-ion battery operating conditions for stability during early cycle.

Keywords: Lithium-ion battery, capacity increasing, electrochemical impedance spectroscopy.

Biography:

Miss. Belfun Arslan graduated from the Department of Chemical Engineering at Izmir Institute of Technology in 2021 and is a master's degree student at Gebze Technical University in the Department of Chemical Engineering. She is an R&D engineer in Mutlu Akü. She is currently working on the state-of-health prediction of lithium-ion batteries and thermal management of Li-ion batteries.