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Comparative Ante-Mortem Studies through Electrochemical Impedance Spectroscopy, Differential Voltage Analysis and Incremental Capacity Analysis on Lithium Ion Batteries

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Abstract : Nowadays, several lithium-ion battery technologies are being commercialized. These chemistries present different properties that make them more suitable for different purposes. However, comparative studies showing the advantages and disadvantages of different chemistries are incomplete or scarce. Different non-destructive techniques are currently being employed to detect how ageing affects the active materials of lithium-ion batteries (LIBs). For instance, electrochemical impedance spectroscopy (EIS) is one of the most employed ones. This technique allows the user to identify the variations on the different resistances present in LIBs. On the other hand, differential voltage analysis (DVA) has shown to be a powerful technique to detect the processes affecting the different capacities present in LIBs. This technique shows variations in the state of health (SOH) and the capacities for one or both electrodes depending on their chemistry. Finally, incremental capacity analysis (ICA) is a widely known technique for being capable of detecting phase equilibria. It reminds of the commonly used cyclic voltamperometry, as it allows detecting some reactions taking place in the electrodes. In these studies, a set of ageing procedures have been applied to commercial batteries of different chemistries (NCA, NMC, and LFP). Afterwards, results of EIS, DVA, and ICA have been used to correlate them with the processes affecting each cell. Ciclability, overpotential, and temperature cycling studies envisage how the charge-discharge rates, cut-off voltage, and operation temperatures affect each chemistry. These studies will serve battery pack manufacturers, as for common battery users, as they will determine the different conditions affecting cells for each of the chemistry. Taking this into account, each cell could be adjusted to the final purpose of the battery application. Last but not least, all the degradation parameters observed are focused to be integrated into degradation models in the future. This fact will allow the implementation of the widely known digital twins to the degradation in LIBs.

Keywords : lithium ion batteries, non-destructive analysis, different chemistries, ante-mortem studies, ICA, DVA, EIS
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