Investigating the Temperature-Dependent Ageing Mechanisms and Energy Efficiency of Commercial Lithium-Ion Batteries

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Lithium-ion batteries (LIBs) stand as the foremost choice in energy storage, finding its application in portable, electric vehicles, and even to grid-level energy storage. The projected surge in LIB adoption is substantial, accompanied by a corresponding increase in demand for raw materials. Investing in the development of long-lasting LIBs and operational protocols that can reduce the rate of ageing is pivotal not only for reducing environmental impact but also for sustaining a stable supply of LIBs.

The ageing of LIB cells is influenced by the materials used, architecture of the battery, temperature, charge/discharge rate and architecture of the battery cells. The lifetime is generally determined by the stability of materials – e.g. formation of solid-electrode interphase (SEI), lithium plating and decomposition of active materials or electrolyte and loss of contact being the main contributors.

We have demonstrated experimentally the Arrhenius plots as an efficient tool to understand the rate of battery cell ageing over its operational temperature range[1,2]. The V-shaped Arrhenius diagrams depicting rate of ageing as a function of inverse temperature depict two aging mechanisms: lithium plating at low temperature and the growth of the solid electrolyte interphase (SEI) in high temperature range. A local minimum is observed where the dominating ageing mechanisms intersect, and is studied as a function of temperature and C-rate.

Next, energy efficiency of the commercial LIB cells across seven different temperatures and three C-rates is inspected. Efficiency generally increases with temperature and decreases with higher C-rates. Diminishing energy efficiency is also observed as the battery cell ages, especially past the 95% SoH. The results highlight that both rate of ageing and energy efficiency should be considered when operating LIB.

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References

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