Cycle ageing analysis of $LiFePO_4$/graphite cells

Ville Erkkilä [a], Maija Marja-Aho[a], Jari Haavisto [a], Mikko Pihlatie [a]
[a] *VTT Technical Research Centre of Finland Ltd, Biologinkuja 7, Espoo, P.O. Box 1000, FI-02044 VTT, Finland*

E-mail: ville.erkkila@vtt.fi

Battery lifetime testing methods are mainly designed for automotive applications. Although the number of heavy-duty electric commercial vehicles (ECVs), such as city buses, lorries and trucks, is smaller than passenger cars, their impact to energy use and emissions are significant. Different types of ECVs are rapidly being electrified. Compared to passenger cars, ECVs experience significantly differing duty cycles. Considering the complex, non-linear and path dependent lifetime of Li-ion batteries, specific test methods for ECVs are needed. At the moment, the most commercially viable solution in many applications is a vehicle with fast opportunity charging capability and a smaller battery. This, combined with very high usage rate of 10-20 hours per day, presents a very demanding case for battery performance. Therefore, we have performed equally demanding lifetime tests for a set of batteries.

This poster presents the complex ageing patterns of twelve large format 20 Ah $LiFePO_4$/graphite cells cycled with symmetric (2.5C/2.5C) and asymmetric (2.5C/1C and 1C/2.5C) high currents and with different state-of-charge (SOC) windows. The SOC windows were 0-100 %, 0-80 %, and 20-100 %. During the cycle life testing, forced air cooling was used to minimize thermal cycling. The ambient temperature was kept at 23 ±1 °C.

The results show clearly that high charging and discharging currents close to maximum value speed up the cell degradation. Lowering either the charge or the discharge current thus extends the cell lifetime as expected. High charge current seems to be more detrimental than high discharge current. Normally, a higher average SOC during cycling leads to increased capacity fade. However, in our tests this is observed only in combination with high charging current. Asymmetric charge and discharge currents are causing some unexpected degradation phenomena. Differential voltage analysis reveals irreversible loss of active lithium as the main degradation mechanism. Post-mortem studies of the cycled and un-cycled battery anodes revealed increased lithium content on the surface of the cycled anode detected by X-ray photoelectron spectroscopy (XPS) and Secondary Ion Mass Spectrometry (SIMS) methods. Also small amounts of Fe was found by Energy-Dispersive X-ray spectroscopy (EDX) and SIMS methods on the cycled anode surfaces, indicating that Fe has dissolved from the cathode material and migrated on the anode surface. Significant inhomogeneous surface degradation and layer formation was detected on the cycled anodes.