Ageing studies on commercial 18650 batteries used in Tesla model S electric vehicles

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Li-ion batteries will be attractive energy storage devices for years to come. They benefit from a high specific capacity combined with high cyclability. In order to advance in conventional lithium-ion technology it is necessary to develop new materials and to improve existing concepts. In particular, the latter includes ageing studies on, *e.g.*, commercially available batteries. Such studies help predict the lifetime of the batteries and assist in identifying the main failure mechanisms connected to lithium plating, passivating surface films, co-intercalation or dissolution of metal ions, for example.

In the present study commercial 18650 lithium-ion battery cells were used to perform fundamental cycle and calendar ageing studies. For this purpose systematic electrochemical tests were carried out at three different temperatures, viz. – 25 °C, 40 °C and 60 °C. The cells were charged and discharged via galvanostatic cycling at different C rates ranging from 0.3 C to 1 C. For comparison, calendar ageing was electrochemically monitored at four different SOCs (100%, 80%, 50% and 20%). After the various ageing steps the capacity fade and the increase in AC and DC impedance was determined.

It turned out that temperature has little effect on calendar ageing. The capacity fade (5% at most) increases with increasing SOC. In contrast to this behavior, during cycle ageing temperature has a much larger effect on capacity fade and DC impedances. As an example, after 500 cycles at 25 °C (or 40 °C) the capacity fade is approximately 12 % of the initial value while at 60 °C the fade has reached already 22%. DC impedances measured revealed the same trend. First post mortem analyses have shown that there are indications that ageing observed might be related to changes of the solid electrolyte interphase. Hence, the changes in electrochemical performance were correlated with the thickness and composition of the SEI formed. In particular, we quantitatively measured the formation of LiF via ion exchange chromatography.