Effect of calendering $LiFePO_4$ electrodes

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In a typical process involving the production of lithium-ion batteries, the electrodes are compressed in a process known as calendering.[1] Calendering of the electrodes has been known to increase the volumetric capacity of the cells, increase adhesion, and improve the rate capability.[2] Typically the rate capability is suggested to increase to do increased interparticle contact in the electrodes.[3,4]

In this paper, changes in the electrode-Al interface will be investigated as a contributor to impedance changes after the calendering process.[5]

$LiFePO_4$ electrodes were coated on Al foil. The electrodes had a coating density of 1.4 g cm^{-3} before calendering and 2.5 g cm^{-3} after calendering.

Symmetric $LiFePO_4$ cells were fabricated and cycled. Figure 1 show the Nyquist plots of the cells made with uncalendered and calendered electrodes. The decrease in cell impedance was most pronounced in the high-frequency semicircle, which has been recently attributed to the electrode-Al interface.[6]

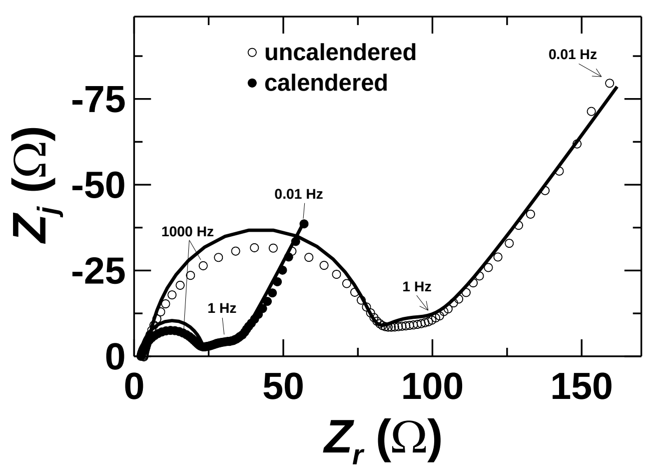

Figure 1. Nyquist plots of cycled LiFePO4 symmteric cells made with uncalendered and calendering electrodes. Solid line represents fitted data.

LiFePO4/Li cells were constructed with uncalendered and calendered electrodes. Figure 2 shows the capacity retention of these cells as a function of current delivered. The cells made from calendered electrodes show much better capacity retention at high rates.

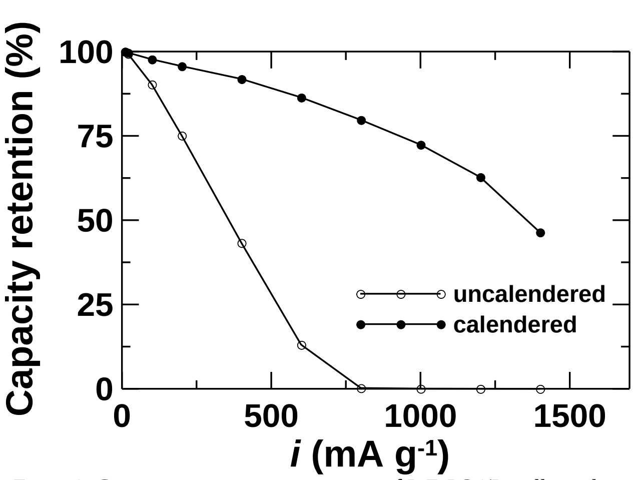

Figure 2. Capacity retention versus current of LiFePO4/Li cells made with uncalendered and calendered electrodes.

The decrease in impedance could have been seen from being either from changes in interparticle contact or changes in the electrode-Al interface. Figure 3 shows the sheet resistant of $LiFePO_4$ electrodes before and after calendering. The sheet resistance was much lower after calendering for the electrodes on Al, whereas the sheet resistance was comparable for uncalendered and calendered electrodes on PET. This indicates that the electrode-Al interface is a major contributor to changes in the cell impedance after calendering.

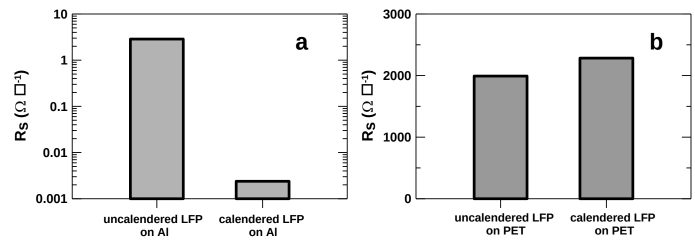

Figure 3. Sheet resistance before and after calendering $LiFePO_4$ electrodes on a) Al foil and b) PET film

Figure 4 shows an SEM image of the Al foil underneath $LiFePO_4$ electrodes that were uncalendered and calendered. The plastic deformation of Al foil by the electrode particles is clearly visible. Changes in the contact impedance due to plastic deformation was analyzed with theory used in isotropic conductive films- and will be presented in this paper.

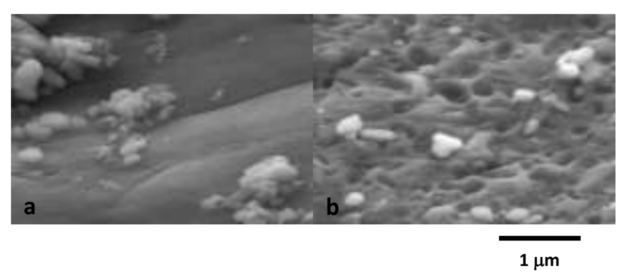

Figure 4. SEM images of the aluminum surface underneath a) uncalendered and b) calendered $LiFePO_4$ electrodes.

References

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