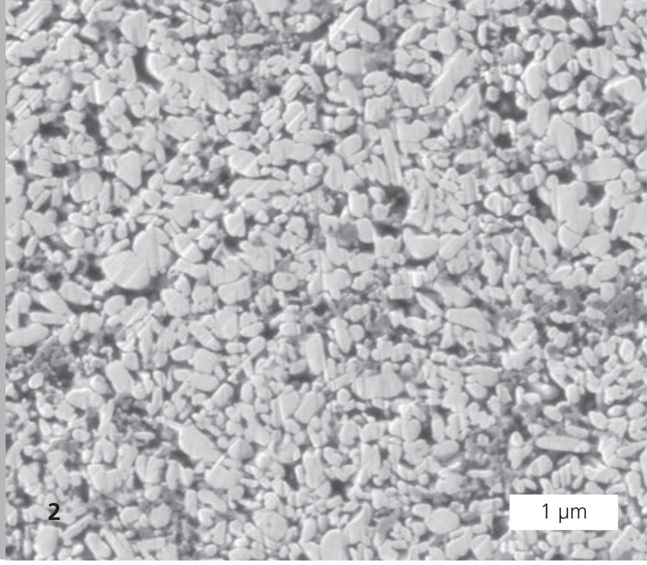

ENERGY

TOWARDS AN ENVIRONMENTALLY BENIGN MANUFACTURING OF LITHIUM-ION BATTERIES

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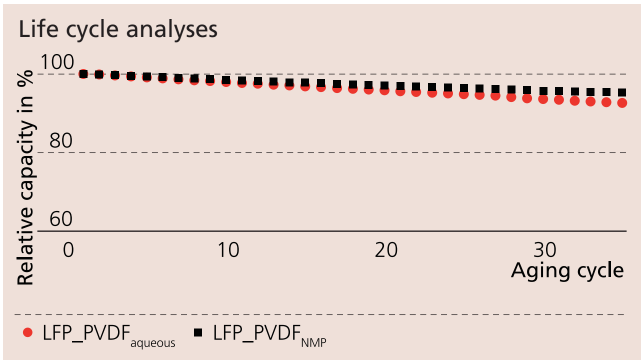
Reduction of manufacturing costs is still the main challenge for the large scale market introduction of Li-ion batteries in e-mobility as well as stationary energy storage. Value chain analysis of Li-ion battery production showed that the electrode manufacturing process is one of the major cost drivers. Therefore, the focus of our work is the development towards environmentally friendly and energy-efficient manufacturing processes. We emphasize the following topics: time- and energy-efficient mixing processes, environmentally friendly, aqueous electrode slurry recipes and energy-reduced drying processes. Slurries processing and electrodes manufacturing were investigated at the IKTS battery pilot line.

Commonly, organic solvents like N-methylpyrrolidone (NMP) are used in positive electrode manufacturing process, bearing potential health and safety risks. Furthermore, additional investments for safety equipment and high fabrication costs due to electrode drying and the recycling of the solvent are necessary. Development of aqueous formulations of the slurry for the manufacturing of Li-ion battery positive electrodes has been growing in interest due to potentially lower cost and environmental friendliness. Water-based slurries are state of the art for the production of graphite-based anodes. For the positive electrodes, it is still challenging to provide (i) good dispersion of the active material, carbon additive and binder, (ii) proper rheological behavior adjusted to the coating technology, (iii) assurance of the mechanical integrity of the electrode (good adherence between the components of the coating and between coating and current collector) and (iv) compatibility with the aluminum current collector with respect to corrosion behavior. To develop water-based slurries for positive electrode, we used carbon-coated $LiFePO_4$ (Südchemie) and carbon black (Timcal) as active material and conductive agent powders, respectively. For the binder, PVDF of Solvay combined with carboxymethyl cellulose (CMC) of Walocel as dispersing agent were used. Pilot scale equipment was used in order to study the correlations between mixer technology, slurry composition, slurry processing and the electrochemical properties like capacity, rate capability and cycling stability. The coating components were mixed using two different mixers (Netzsch planetary mixer and Eirich intensive mixer). The coating of the aluminum current collector was carried out by using the doctor blade method on a roll-to-roll coating system. After that, the electrodes were compressed using a calendar. The manufactured electrodes were characterized first in half cell arrangement versus lithium in order to evaluate the differences in the capacity and rate capability. For the life cycle experiments, the electrodes were assembled in full cell arrangement versus graphite anode. For both arrangements CR3220 button cells were used. The diagram presents results from cycle tests of water-based and NMP-based $LiFePO_4$ cathodes. The comparison shows that a successful aqueous processing is possible in a pilot scale. Performance and durability of the resulting electrodes are comparable to organic solvent based electrodes.



1 *Electrode casting at pilot scale.*
2 *SEM picture of water-based $LiFePO_4$ cathode.*

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