

Processing of water-based cathodes for lithium ion batteries – influence of various PVDF latex binder systems on the mechanical and electrochemical properties

Andreas Weber, Ulrike Kaufmann, Marcus Müller, Werner Bauer
Institute for Applied Materials – Energy Storage Systems

Karlsruhe Institute of Technology

The replacement of solvent-based electrode manufacturing with a water-based process implies a significant reduction of the manufacturing costs. However, the substitution of NMP by water poses multiple challenges and requires many adjustments to the process in order to ensure identical or even better process and product properties. Besides the reduced colloidal stability of the slurries, especially the interaction of the cathode materials with water must be taken into account. Cathode materials usually form hydroxides when they are in contact with water due to a Li^+/H^+ exchange reaction. The resulting pH value depends on the specific cathode material and the time of exposure, but is usually beyond the stability range of the current collector foil. At a higher pH value, a corrosive attack of the aluminum foil takes place. This can lead to the detrimental formation of water-soluble aluminum species, general corrosion and pitting of the aluminum foil, and to the generation of gas bubbles, which are trapped inside the electrode layer. Moreover, common PVDF binder systems are not suitable for water-based processing as PVDF is insoluble in water. Therefore, novel PVDF latex binders are being developed by the industry and are the subject of this study.

Comparing three different PVDF latex binders – a commercially available, non-functionalized homopolymer, an experimental, functionalized homopolymer and an experimental, functionalized hexafluoropropene (HFP)-copolymer – both the adhesive strength and the electrochemical performance of full-cells (C-rate capability and capacity retention) were investigated. Each of the aforementioned binders was applied in several slurry compositions differing in the use of phosphoric acid, pre-treated $\text{LiNi}_{0.6}\text{Mn}_{0.2}\text{Co}_{0.2}\text{O}_2$, binder content and graphite.

The processing of both homopolymer binders resulted in homogeneous coatings while the HFP-copolymer binder showed a tendency to form agglomerates. By temperature treating the coatings a rise in adhesion strength was observed. Throughout all slurry compositions the slurries consisting only of pristine $\text{LiNi}_{0.6}\text{Mn}_{0.2}\text{Co}_{0.2}\text{O}_2$, carbon black, carboxymethylcellulose and the respective binder yielded the worst adhesion strength and yet the best capacity retention over the first 300 cycles.