Effect of Chemical Properties of Poly(vinylidene fluoride) (PVDF) Binder on the Surface Chemistry and Electrochemical Behavior of the Anodes of Lithium Ion Batteries

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In the rechargeable lithium ion batteries, anodes predominantly consist of graphite bound by polymeric binders like poly(vinylidene fluoride) (PVDF). Polymeric binder, which is necessary to provide sufficient mechanical strength to the electrodes, can be subjected to electrochemical reaction between lithium ions and electrolyte, which takes place at the carbon surface. It is known that the type and amount of the binder affect not only mechanical properties but also electrochemical performance of anodes such as electrochemical capacity, efficiency, charging-discharging rate and cyclic life.

In the previous presentations, we have shown that interaction between graphite and PVDF influences the viscosity of slurries as a processing parameter, and it causes the different homogeneity of distribution of PVDF on the graphite surface in final composite anodes. Also it has been shown that physical properties of the anodes such as adhesion and cohesion strength are affected by the crystallinity of PVDF and nature of carbon materials. These surface chemistry and morphology are influenced by the chemical properties of PVDF, which is manifested by the –OH functional group modified PVDF and high molecular weight PVDF.

In this report, we have examined the effect of chemical properties of binders on the surface morphology and the binding mechanism of PVDF binders on the surface of carbon materials by using different molecular weight and functionality. Also we have investigated the effect of this interaction on the electrochemical properties of the anodes.

We used 8 kinds of carbon materials: synthetic graphite MV2 (Mitsubishi Chemical Corp., Japan), SFG15, SFG44, SFG75 (Timcal Co. Ltd., Switzerland), KS6, KS15 (Timcal Co. Ltd., Switzerland), and mesocarbon microbeads (MCMB-, Oosaka Gas Chem., Japan); MBC-N (Mitsubishi Chemical Corp., Japan) as amorphous carbon material. Anodes were prepared by mixing carbon slurries that contained each of carbon materials, 1-metyl-2-pyrrolidinone (NMP, anhydrous, Aldrich) as a solvent and 10 wt% solution of poly(vinylidene fluoride) (PVDF) binder (Mw=350k, Kureha, KF#1300) in the same solvent. To investigate the effect of molecular weight and functionality, we used a PVDF with molecular weight of 500k (Atofina, Kynar 301F) and a modified PVDF with –COOH and –OH (Atofina, MKB 212A). And we used alternative solvents such as N,N-dimethylacetamide (DMA) and N,N-dimethylformamide(DMF).

We have performed Quartz Crystal Microbalance (QCM) to investigate the kinetics of adsorption of PVDF on to the carbon surface and the effect of the chemical properties of PVDF on that mechanism. And the electrochemical behavior with different PVDF will be presented.