Recent Development of Electrode materials in Lithium Ion Batteries and Their Reactions

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Lithium ion secondary batteries have widely been utilized as consumers' electronic devices such as cellular phones, personal computers, etc. because of their high electrical density. Furthermore, the onset of pure and hybrid-type vehicles demand in the near future necessitate low cost, environment friendly and thermally stable lithium ion batteries with high power and high energy density.

In the present work, we will present two topics; 1) electronic and local structures of cathode materials of lithium-ion batteries, and 2) enhancement of charge-transfer reaction rate at cathode / electrolyte interface.

Electronic and local structures of cathode materials of lithium-ion batteries [1-4]

Information of the local and electronic structures of cathode materials is important to understand their electrochemical properties. From a classical point of view, in the cathode reaction (electrochemical Li insertions) in 3d-transition metal oxide, 3d-transition metal is expected to experience the reduction process as Li-ion insertions proceed. However, recent theoretical and experimental researches have suggested that oxide ions also have an effect on the electronic transfer process in various oxide compounds. We will introduce our XAS results for 3d-transition metal (Mn, Co, Ti, etc) oxides and phosphate system, LiMPO4 (M = Co, Fe) with the olivine-related structure. X-ray Absorption Spectroscopy (XAS) is the strong method to obtain the information of the electronic state and local structure of these materials. XAS is generally divided into two sections: 1) X-ray adsorption near edge structure (XANES) which indicates X-ray adsorption near-edge structure roughly up to 50 eV from adsorption edge. XANES qualitatively presents the structure of conduction band. 2) extended X-ray adsorption fine structure (EXAFS). In the EXAFS region the photoelectrons have high kinetic energy and single scattering by the neighboring atoms dominates.

Enhancement of charge-transfer reaction rate at cathode / electrolyte interface [5-7]

Enhancement of the interfacial reaction rate is important to fabricate high power density batteries. Recently, we have reported that poly(ethylene glycol) (PEG)-borate ester has the effect of increase in ionic conductivity and transport number of lithium ions or magnesium ions of polymer electrolytes. Since the borate ester groups which act as Lewis acid prefer to interact with anions, the increase in the conductivity and transport number of lithium ions is induced by enhancing the dissociation of the salts in polymer electrolytes. These results indicate that activity of lithium ions in the polymer electrolytes increases by addition of the PEG-borate ester. Therefore, we have attempted and, as a consequence, achieved the enhancement of the reaction rate at the PEGDME based electrolyte/electrode interface using the PEG-borate ester as Lewis acid for the electrolytes.

References

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