Search and analysis for the method of cycle performance recovery aiming for nondestructive reuse of LIB

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Lithium ion batteries (LIBs) are used as a storage device for electric vehicles and their production is recently increasing. Large-scale batteries for electric vehicles are especially expensive because its cathode includes rare metal such as Co(1). But it becomes unavailable after achieving 80% of its initial capacity from a safety point of view. One of solutions for recycle is disassembling the battery and extracting rare metals such as cobalt from its cathode, but this solution also takes high costs. Another approach is replacing degraded battery components and recovering the original cell without disassembling. In our research, recovering the capacity of the degraded cell was successfully achieved by replacing the electrolyte and holding discharged state. The aim of this study is to reveal the recovering factor, and X-ray absorption fine structure (XAFS) measurement was performed to analyze the surface state of the $LiNi_{1/3}Mn_{1/3}Co_{1/3}O_2$ (NMC) cathode.

The laminated cells were assembled using an NMC cathode and a graphite anode. These cells were charged and discharged with current rate of 1C at 60 °C until the capacity was decreased to 80% of the initial capacity. NMC cathodes of some cells were taken out from the cells after discharging or charging up to 4.2 V. These degraded cells were replaced the electrolyte and held its voltage to 2.5 V at 60 °C for 48 h. After the treatment, the cell was disassembled, and another cell was charged until the voltage is achieved to 4.2 V with the current rate of 1C. Charged cell was also disassembled. The 4 kinds of NMC cathodes were prepared for XAFS measurement in order to evaluate the valence of surface Ni species. The XAFS measurement at Ni L-edge was carried out at BL-11 of the SR center (Ritsumeikan University) with total electron yield (TEY) mode.

Fig. 1 shows the Ni L-edge X-ray absorption near edge structure (XANES) spectra of the degraded cathodes after charged or discharged, cathodes after the treatment with the differential spectra. The peak at 854 eV is shown the existence of lower valence Ni species, and the peak at 856 eV is shown that of higher valence Ni species. Comparing these differential spectra, the amplitude of after treatment was larger than that of after degradation. This means that the redox activity of Ni species was recovered by replacing electrolyte and holding discharge state.

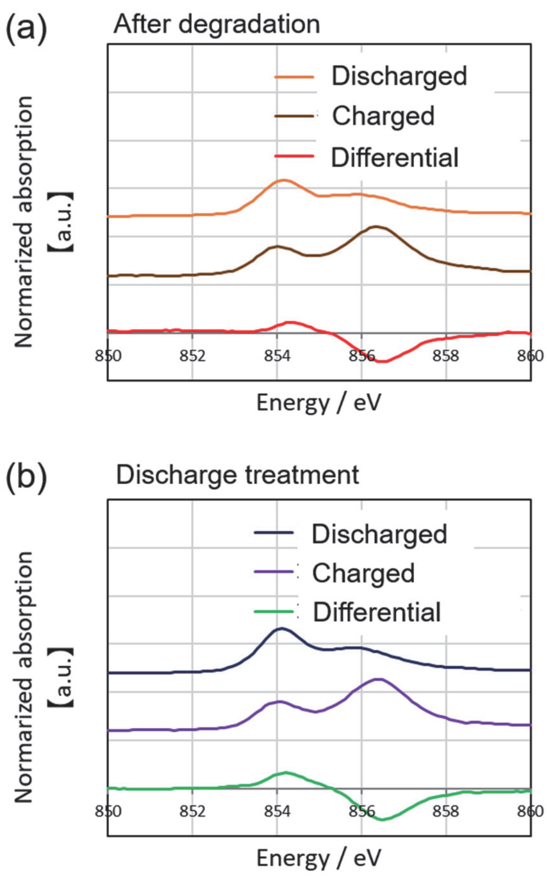

Fig. 1 Ni L-edge XANES spectra of NMC cathodes (a) after degradation and (b) with discharge treatment.

References

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