Supporting Information

Performance Improvement and Failure Mechanism of $LiNi_{0.5}Mn_{1.5}O_4$ / Graphite Cells with Biphenyl Additive

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The CR2016-size half cells were used to evaluate $LiNi_{0.5}Mn_{1.5}O_4$ materials with the control electrolyte: 1.0M $LiPF_6$ ethylene carbonate (EC)/ethylmethyl carbonate (EMC)/fluroethylene carbonate (FEC) (10/70/20, v/v) with 2 wt% Lithium bis(oxalate)borate (LiBOB). The positive electrode consists of 80:10:10 wt% of $LiNi_{0.5}Mn_{1.5}O_4$, super-P carbon, and PVDF, the anode is lithium metal. As shown in Fig.S1, the capacity retention decreases to 80% after 458 cycles at 0.5C rate charge/discharge in room temperature with the control electrolyte.

Fig. S1 The charge/discharge performances of $LiNi_{0.5}Mn_{1.5}O_4$/Li half cell in room temperature

The cycled electrodes in Fig.6-8 are all calcined at 600℃ in air. Fig. S2 shows the XRD patterns of the cycled $LiNi_{0.5}Mn_{1.5}O_4$ without heat-treatment, which contains the residual binder and conductivity carbons. But the materials used in Fig.S2 are not recovered from the same cells with the materials in Fig. 6-8. The cells for Fig. 6-8 are stopped at 110 cycles and then are disassembled. The cells for Fig. S2 are obtained after 124, 173 and 196 cycles for 1BP, 0BP and 0.5BP, respectively(as shown in Fig. 3a), then storage a half years in room temperature(almost zero voltage when disassembling). The intensity of {220} plane of the cycled $LiNi_{0.5}Mn_{1.5}O_4$ materials before heat-treatment doesn't become stronger than fresh one. The decrease in peak intensity and broadening in peak shape (shown in Table S1) indicate a decrease in particle size and an increase in defects of the cycled $LiNi_{0.5}Mn_{1.5}O_4$ materials. In fact, the SEM images of the cycled $LiNi_{0.5}Mn_{1.5}O_4$ using 1BP electrolyte with and without heat-treatment are shown in Fig. S3, which indicate clearly that the particle size of cycled $LiNi_{0.5}Mn_{1.5}O_4$ become smaller. Further, the BP polymer films on the cathode surface can protect the cathode indeed from structure destruction during the prolonged cycles.

Table S1. The parameters from XRD patterns(Fig. S2) of the cycled $LiNi_{0.5}Mn_{1.5}O_4$ without heat-treatment

	Intensity of {111} planes	FWHM of {111} planes	Lattice parameter *a* / Å
Fresh	1438	0.143	8.1735
0BP	958	0.189	8.1972
0.5BP	1289	0.154	8.1925
1BP	1318	0.148	8.1811

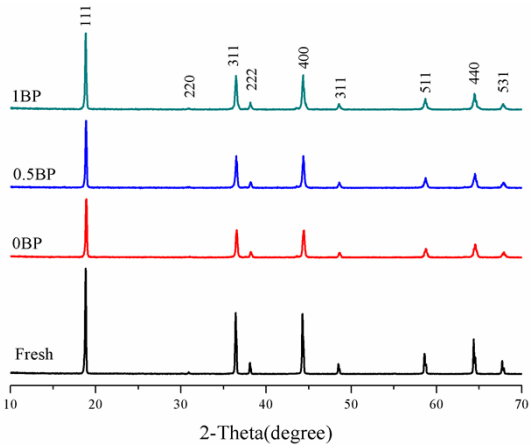

Fig. S2 The XRD patterns of the cycled $LiNi_{0.5}Mn_{1.5}O_4$ without heat-treatment

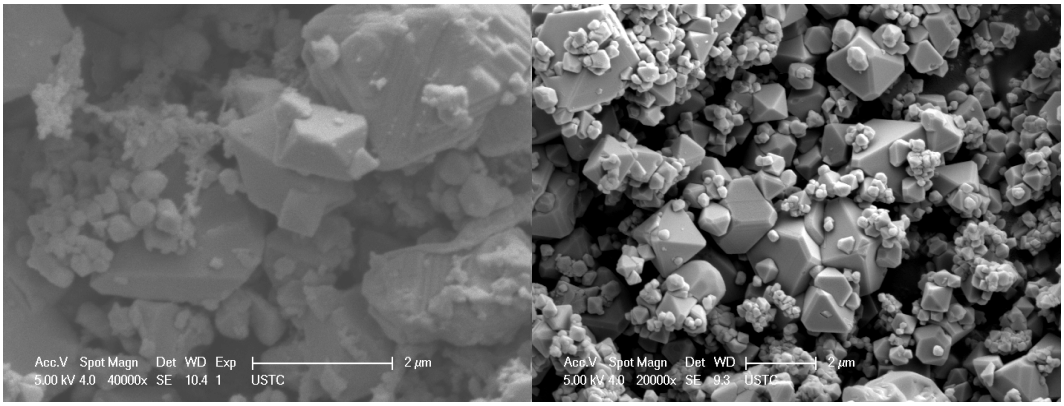

Fig. S3 The SEM images of the cycled $LiNi_{0.5}Mn_{1.5}O_4$. The cycled $LiNi_{0.5}Mn_{1.5}O_4$ samples were recovered from the $LiNi_{0.5}Mn_{1.5}O_4$/graphite cells after 110 cycles using 1BP electrolyte, the left is without heat-treatment at 600℃ in air and the right is with the heat-treatment.