# Supporting Information

Preparation and Characterization of $Li_{1.12}K_{0.05}Mn_{0.57}Ni_{0.24}Nb_{0.02}O_2$ Cathode Material with Highly Improved Rate Cyclic Performance for Lithium Ion Batteries

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**Table 1** Refined lattice parameters of LMN and LMN-K/Nb.

| sample | | LMN | | LMN-K/Nb | |
|---|---|---|---|---|---|
| | | LMO | LMNO | LMO | LMNO |
| Lattice parameters (Å) | $a$ | 4.9641 | 2.8606 | 4.9558 | 2.8725 |
| | $b$ | 8.5631 | | 8.5827 | |
| | $c$ | 5.0241 | 14.2608 | 5.0337 | 14.2754 |
| $I_{003}/I_{104}$ | | 2.283 | | 1.656 | |
| Reliability and weighted factors | $R_{wp}$ (%) | 9.6 | | 5.4 | |
| | $R_p$ (%) | 6.8 | | 5.2 | |
| | $\chi^2$ | 2.1 | | 1.8 | |

**Table S2** The fitting parameters for the Nyquist plots.

| | 3rd cycle discharge to 3.5 V | | | 50th cycle discharge to 3.5 V | | |
|---|---|---|---|---|---|---|
| | $R_e$/Ω | $R_{sf}$/Ω | $R_{ct}$/Ω | $R_e$/Ω | $R_{sf}$/Ω | $R_{ct}$/Ω |
| LMN | 1.83 | 45.52 | 505.71 | 2.18 | 180.53 | 1325.32 |
| LMN-K/Nb | 1.47 | 13.58 | 90.63 | 2.02 | 50.36 | 266.16 |

**Table S3** Comparison of electrochemical performance of Li-rich oxides.

| Materials | Initial coulomb efficiency | Capacity-current density | Cycling performance (cycles) | Ref. |
|---|---|---|---|---|
| $Li_{1.12}K_{0.05}Mn_{0.57}Ni_{0.24}Nb_{0.02}O_2$ | 77.2% | 244 mAh $g^{-1}$ at 0.1 C<br>161 mAh $g^{-1}$ at 2 C<br>145 mAh $g^{-1}$ at 5 C | 96% at 0.1 C (100)<br>88% at 2 C (200) | This work |
| $Li_{1.117}K_{0.05}Mn_{0.583}Ni_{0.25}O_2$ | 71.7% | 229 mAh $g^{-1}$ at 0.1 C<br>145 mAh $g^{-1}$ at 2 C<br>100 mAh $g^{-1}$ at 5 C | 98% at 0.1 C (100)<br>95% at 2 C (200) | [1] |
| $Li_{1.2}Ni_{0.133}Co_{0.133}Mn_{0.534}O_{1.8}F_{0.2}$ | 74% | 212 mAh $g^{-1}$ at 0.1 C<br>150 mAh $g^{-1}$ at 0.2 C<br>50 mAh $g^{-1}$ at 1 C | 80% at 0.1 C (100) | [2] |
| $Li_{1.17}Ni_{0.25}Mn_{0.58}Mg_{0.02}O_2$ | 78.1% | 228 mAh $g^{-1}$ at 0.2 C<br>137 mAh $g^{-1}$ at 2 C<br>104 mAh $g^{-1}$ at 5 C | 95% at 0.2 C (100) | [3] |
| $Li_{1.2}Ni_{0.18}Co_{0.18}Mn_{0.18}Ti_{0.26}O_2$ | 60% | 175 mAh $g^{-1}$ at 0.1 C<br>105 mAh $g^{-1}$ at 1 C<br>82 mAh $g^{-1}$ at 2 C | 97% at 0.1 C (182) | [4] |
| $Li_3PO_4$-coated $Li_{1.2}Mn_{0.54}Ni_{0.13}Co_{0.13}O_2$ | 75.78% | 226 mAh $g^{-1}$ at 0.1 C | 78% at 1 C (100) | [5] |
| $Li_3PO_4$-coated $Li_{1.2}Mn_{0.6}Ni_{0.2}O_2$ | 77% | 240 mAh $g^{-1}$ at 0.1 C<br>159 mAh $g^{-1}$ at 1 C | 88% at 0.1 C (50)<br>84% at 1 C (50) | [6] |
| $LiAlO_2$-coated $Li_{1.2}Ni_{0.2}Mn_{0.56}O_2$ | 74.9% | 237 mAh $g^{-1}$ at 0.06 C<br>213 mAh $g^{-1}$ at 0.2 C<br>112 mAh $g^{-1}$ at 5 C | 91% at 0.2 C (100) | [7] |
| $Li_{1.2}Mn_{0.6}Ni_{0.2}O_2$ (Sol-freeze-drying method) | 61% | 242 mAh $g^{-1}$ at 0.2 C<br>148 mAh $g^{-1}$ at 2 C<br>84 mAh $g^{-1}$ at 5 C | 96% at 0.2 C (100) | [8] |
| $Li_{1.2}Ni_{0.2}Mn_{0.6}O_2$ (Electrolyte additive) | 70.2% | 238 mAh $g^{-1}$ at 0.1 C<br>170.0 mAh $g^{-1}$ at 1 C<br>100 mAh $g^{-1}$ at 5C | 80% at 2 C (200) | [9] |
| $Li_{1.2}Mn_{0.55}Ni_{0.15}Co_{0.1}O_2$ (Electrolyte additive) | 70.03% | 248mAh $g^{-1}$ at 0.1 C | 61% at 0.1 C (200) | [10] |

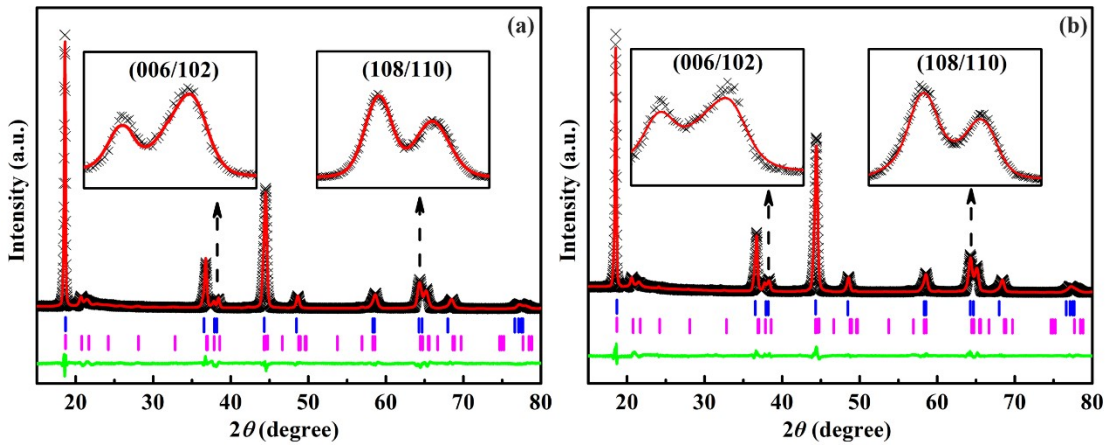


**Fig. S1** Rietveld refinement of the XRD patterns for LMN (a) and LMN-K/Nb (b).

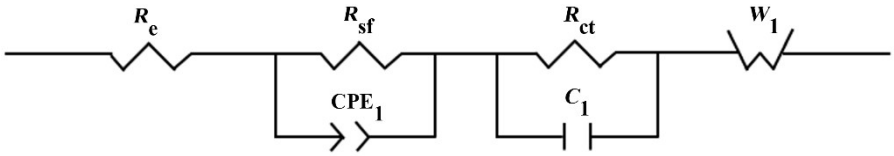


**Fig. S2** The equivalent circuit model for Nyquist plots.

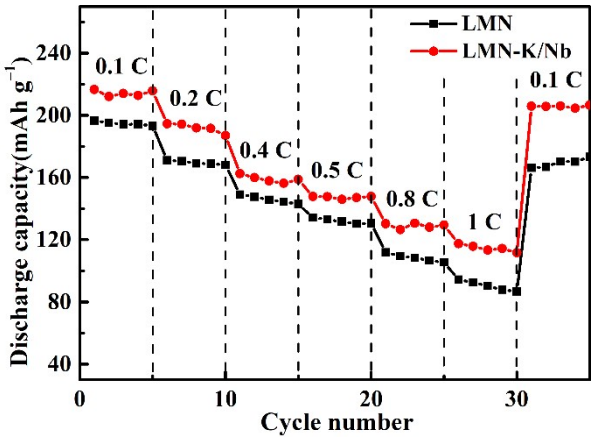


**Fig. S3** The rate performance of the LMN and LMN-K/Nb in full cell at 0.1 C, 0.2 C, 0.4 C, 0.5 C, 0.8 C and 1 C.

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