Electronic Supplementary Material (ESI) for RSC Advances.

Controlled synthesis of concentration gradient $LiNi_{0.84}Co_{0.10}Mn_{0.04}Al_{0.02}O_{1.90}F_{0.10}$ with improved electrochemical property in Li-ion batteries

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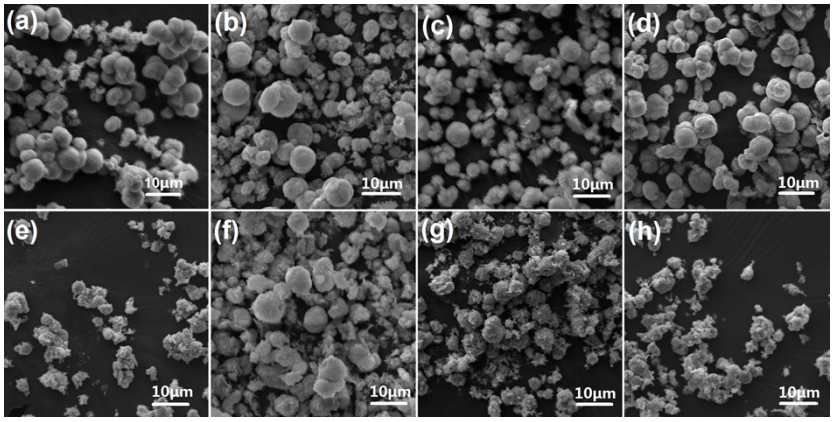

Figure S1 The SEM of MO (a), AFMO (b), FMO (c), AMO (d) and the corresponding lithiated materials LMOA (e), AFLMOA (f), FLMOA (g), ALMOA (h).

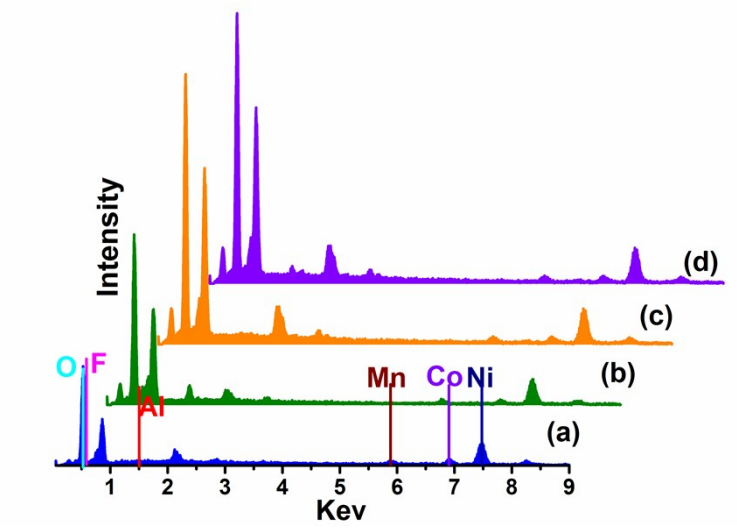

Figure S2 The EDS of MO (a), AFMO (b), FMO (c), AMO (d).

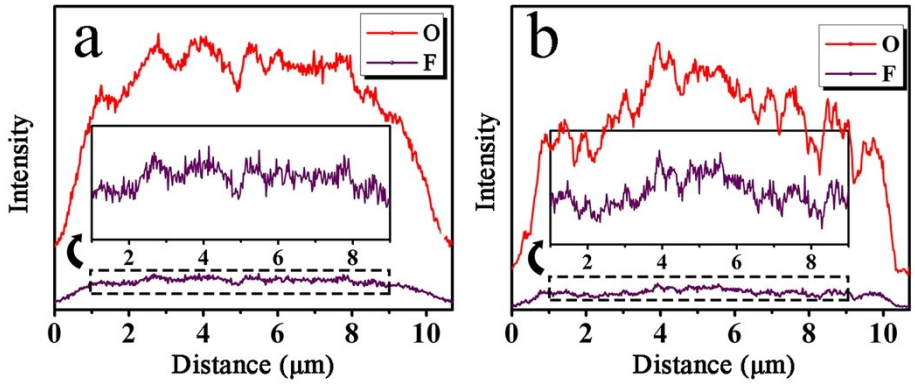

Figure S3 The elements (O and F) distribution line scanning on cross section in single micro-sphere of AFMO (a) and AFLMOA (b)

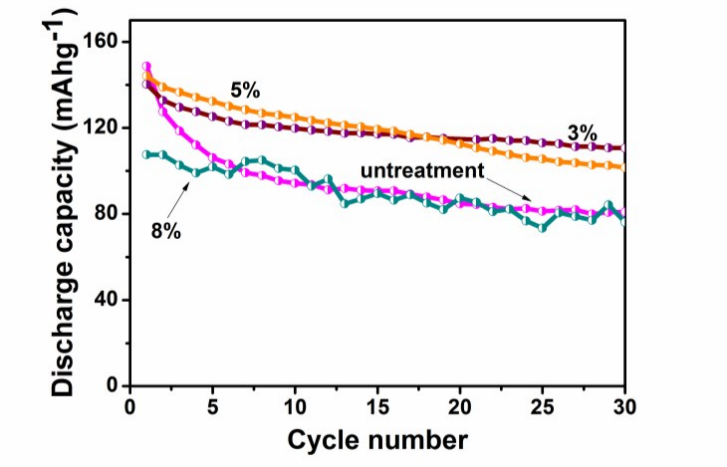

Figure S4 The cycle performances of materials $LiNi_{0.83}Co_{0.10}Mn_{0.07}O_2$ modified by different quantity of $Al^{3+}$and F^- at 160 °C.

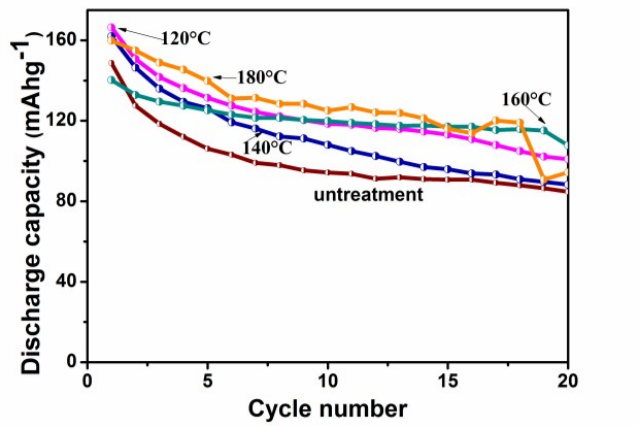

Figure S5 The cycle performances of materials $LiNi_{0.83}Co_{0.10}Mn_{0.07}O_2$ modified by 3% Al^{3+} and F^- at different temperature.

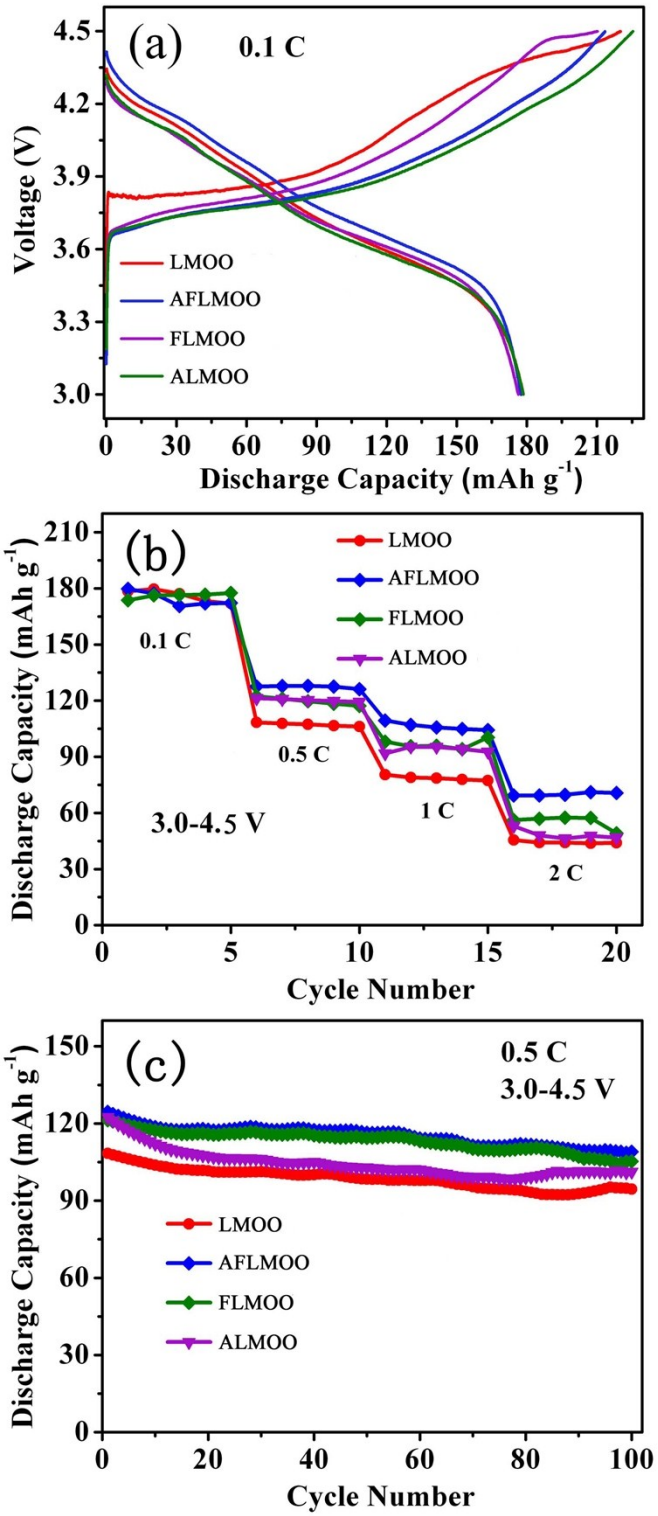

Figure S6 The electrochemical performance of LMO, 3AFLMO, 3FLMO and 3ALMO calcined at O_2: (a) The charge and discharge curves of the materials at the first cycle at 0.1C (20 mAh g^{-1}); (b) The rate performance between 3.0-4.5 V; (c) The cycle performance between 3.0-4.5 V at 0.5C (100 mAh g^{-1}).

The materials have been calcined at 700 ^{o}C under O_2 atmosphere from MO, AFMO, FMO and AMO, which have been named as LMOO, AFLMOO, FLMOO and ALMOO, respectively. The electrochemical performance of materials LMOO, AFLMOO, FLMOO and ALMOO are shown in Fig. S6. Materials LMOO, AFLMOO, FLMOO

and ALMOO show high discharge capacity of around 180 mAh g^{-1} at 0.1 C in the first cycle. The material AFLMOO, FLMOO and ALMOO have better discharge rate performance than LMOO. At the test of cycle performance, the material AFLMOO maintains the highest discharge capacity (93.7% capacity retention) after 55 cycles. The concentration gradient materials calcined under oxygen atmosphere still have better electrochemical performance than the materials without concentration gradient of elements.