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Clusters of α-$LiFeO_2$ nanoparticles incorporated into multi-walled carbon nanotubes: a lithium-ion battery cathode with enhanced lithium storage properties

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Fig. S1

The surface chemical compositions of α-$LiFeO_2$-MWCNT (without plasma) and α-$LiFeO_2$-MWCNT (with plasma) samples were determined by XPS spectra analysis. Fig. S1a and c are the Fe2p photoemission spectra for the untreated and treated α-$LiFeO_2$-MWCNT sample. There is no significant difference between Fig. S1a and c, where both Fe2p spectra are split by the Fe2p spin-orbit effect into the $2p_{3/2}$ and $2p_{1/2}$ peaks. [51] The $2p_{3/2}$ and $2p_{1/2}$ peaks are accompanied by typical satellite peaks. [37, 51] The $2p_{3/2}$ peak at 711.2 eV is corresponding to Fe^{3+}, which suggests that plasma did not change the state of the iron. The O1s spectra for both samples shows the same peaks at 532.1 eV and 530.2 eV, which are assigned to hydroxyl and Fe-O bonds,[51, 52] respectively. However, after plasma treatment, the proportion of the 530.2 eV peak was significant larger than that of the 532.1 eV peak, which indicates more Fe-O bonds formed. This could imply that stronger attachments were fashioned between the plasma oxidized MWCNTs and α-$LiFeO_2$ under the plasma treatment.

References

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Fig. S1

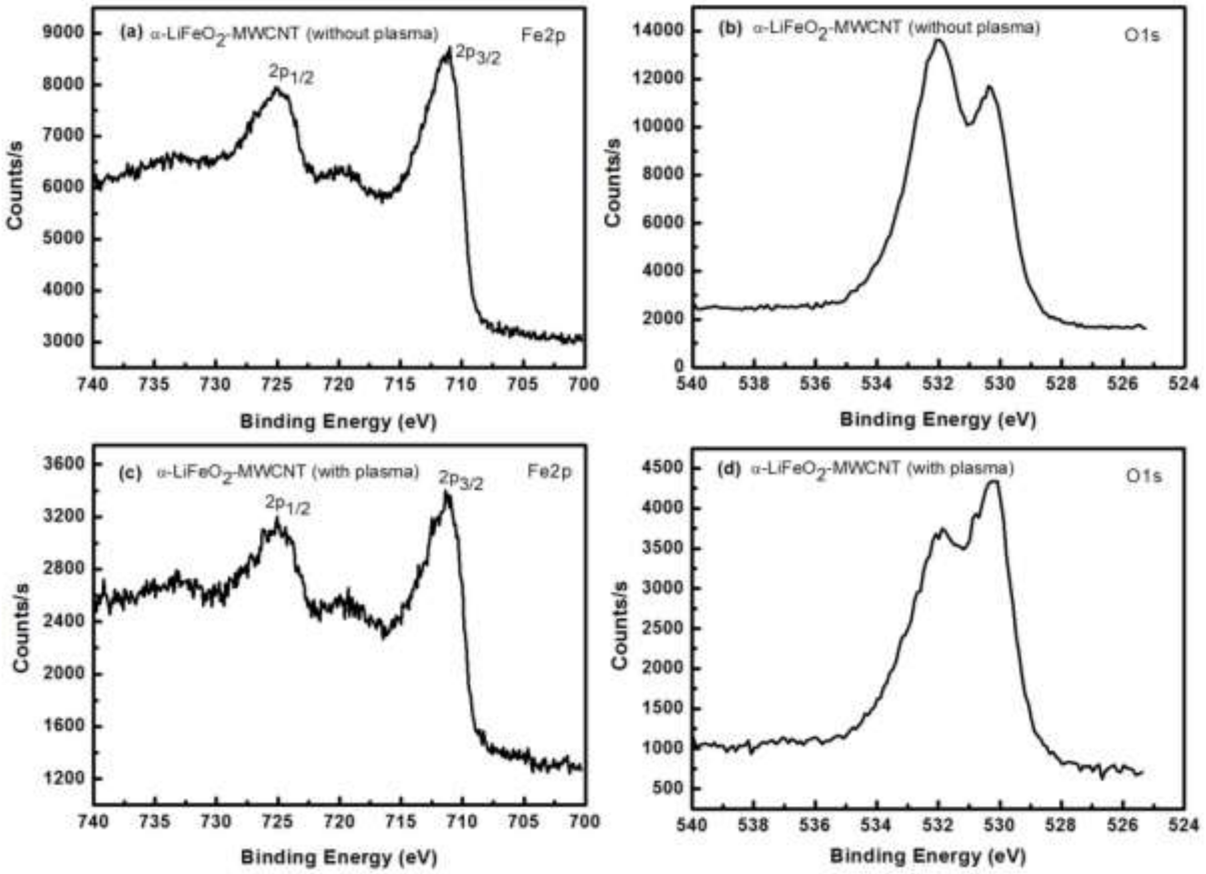

Fig. S1 XPS spectra for Fe2p and O1s of α-$LiFeO_2$-MWCNT (without plasma) (a, b) and α-$LiFeO_2$-MWCNT (with plasma) samples (c, d).

Fig. S2

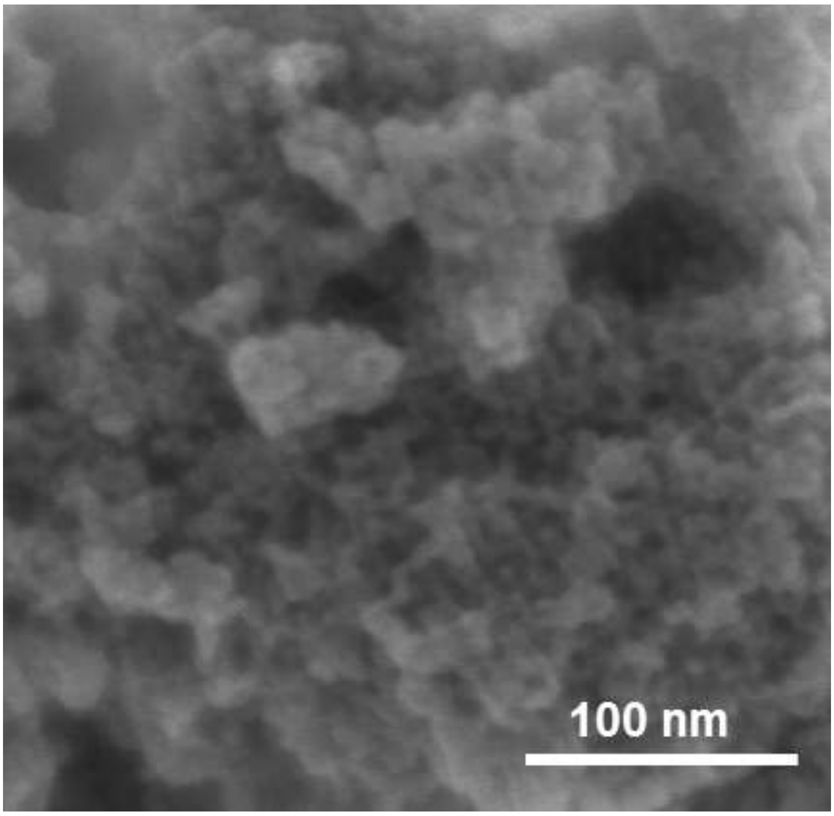

Fig. S2 High-resolution image of a single nanocluster of α-$LiFeO_2$, showing very tiny nanoparticles joined in a porous architecture.

Fig. S3

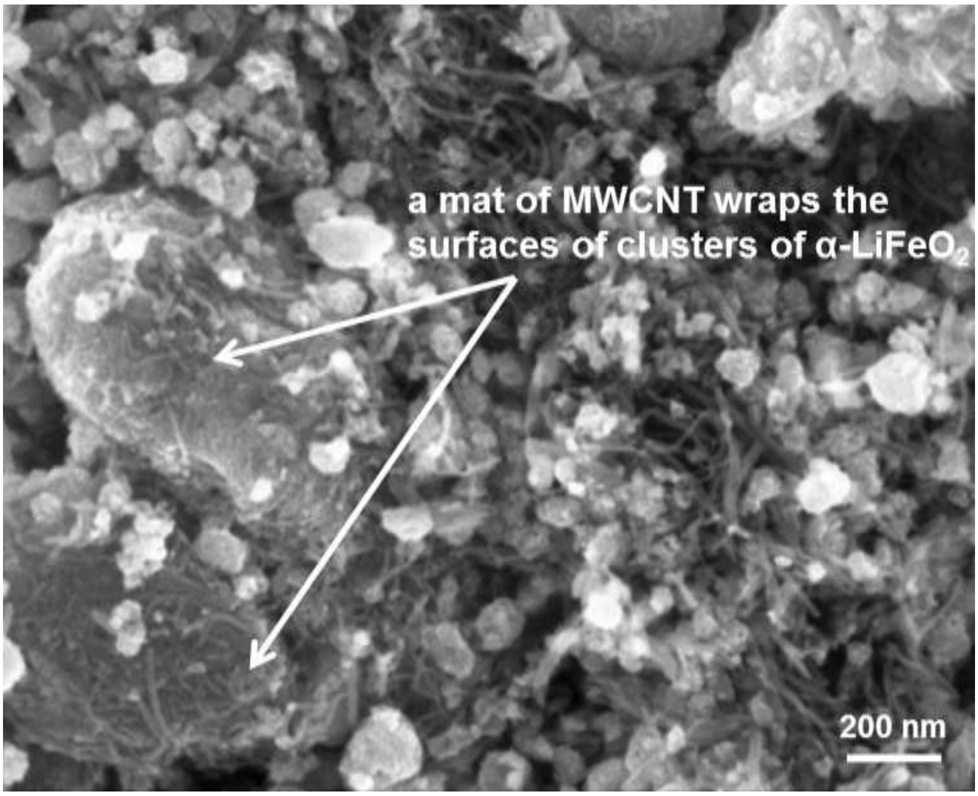

Fig. S3 SEM image of α-$LiFeO_2$-MWCNT (with plasma) nanocomposite. A mat of MWCNTs wraps clusters of α-$LiFeO_2$ and some α-$LiFeO_2$ nanoparticles are attached to the MWCNTs.

Fig. S4

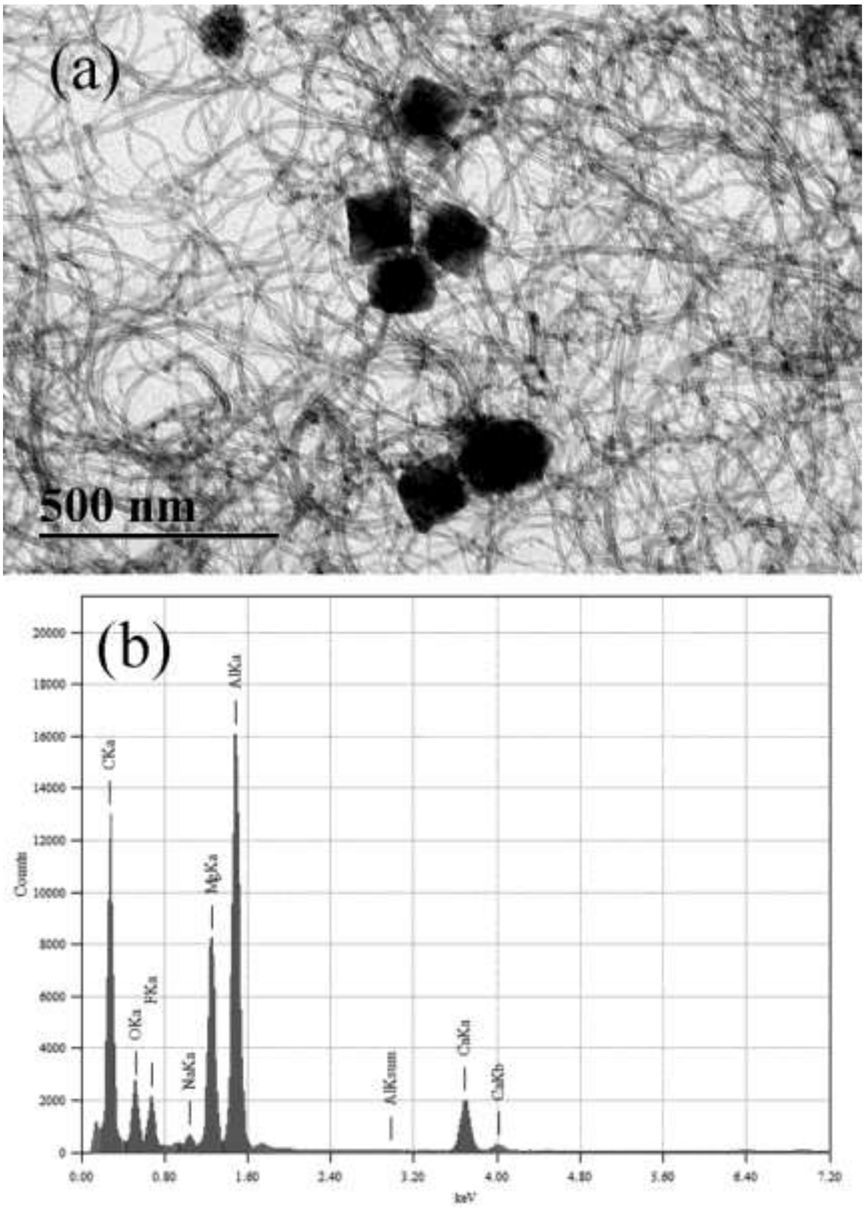

Fig. S4 Contamination observed in the original sample of multi-walled carbon nanotubes: (a) a bright-field image showing contaminating particles (dark); (b) an EDX spectrum of a contaminating particle.

Fig. S5

Fig. S5 shows the variation in the cell capacity as a function of the applied charge-discharge rate, expressed in C rate. The α-$LiFeO_2$-MWCNT (with plasma) electrode shows an improved rate capability over the α-$LiFeO_2$ electrode. The conducting MWCNT component could increase the electron transfer rate and reduce the charge transfer resistance within the electrode,[38-40] leading to a higher rate capability for the α-$LiFeO_2$-MWCNT (with plasma) electrode. There is no significant difference in discharge capacity between the two electrodes at the moderate current rate of 0.1 and 0.5 C. This could be because Li^+ insertion/extraction is sufficient at a relatively low charge/discharge rate. The difference between the lithium storage capacities of the electrodes increased with increasing charge/discharge rate and became significant at the very high current rate of 10 C. This result confirms that the homogeneous dispersion and intimate connectivity between α-$LiFeO_2$ and MWCNTs can significantly improve the kinetics of the α-$LiFeO_2$-MWCNT (with plasma) electrode, giving the α-$LiFeO_2$-MWCNT (with plasma) electrode better rate capability.

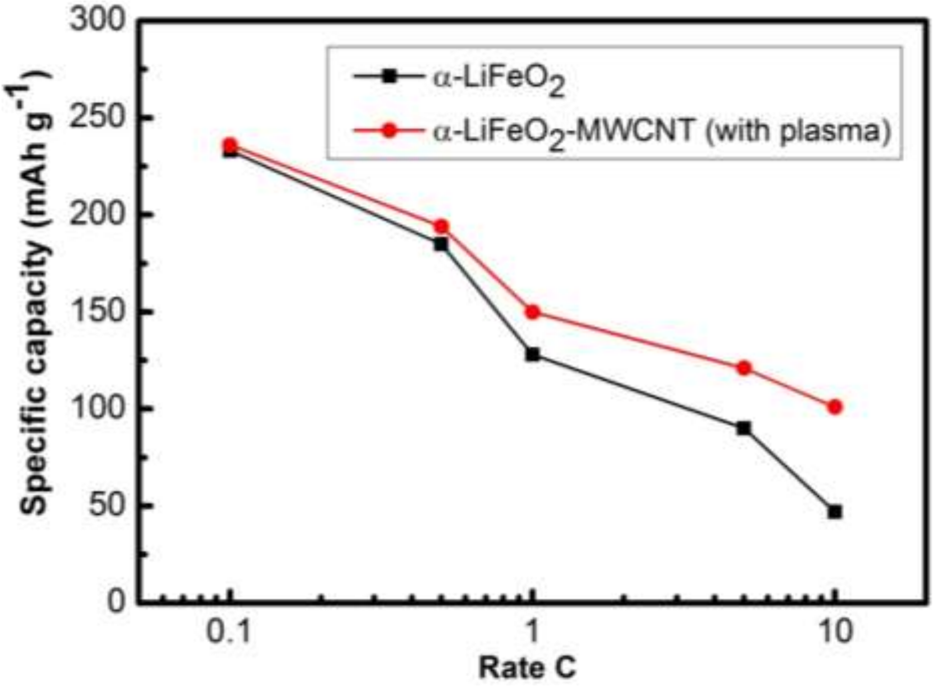

Fig. S5 Rate capability at different current rates of 0.1, 0.5, 1, 5, and 10C.

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