Fe$_2$O$_3$-Fe$_3$C heterostructure encapsulated into carbon matrix for lithium-ion battery anode

Experimental
Synthesis
1 g ferric chloride (Alfa Aesar Co.), 1 g melamine (Sinopharm Chemical Reagent Co.) and 1 g glucose (Sinopharm Chemical Reagent Co.) were added into 30 mL ethanol under stirring and heated to 80 °C until forming a uniform turbid liquid. The turbid liquid was moved into an oven and dried to powder at 80 °C. Then the powder was heated to 800 °C for 4 h in N$_2$ atmosphere with a heating rate of 4 °C min$^{-1}$. The prepared powder was Fe-Fe$_3$C@C. Fe$_2$O$_3$-Fe$_3$C@C, Fe$_2$O$_3$@C and Fe$_2$O$_3$ were obtained by calcining Fe-Fe$_3$C@C powder in the air at 400 °C for 3 h and 5 h and 800 °C for 3 h, respectively, with 5 °C min$^{-1}$ heating rate. The Fe$_3$C@C was obtained by stirring Fe-Fe$_3$C@C in 50mL 4wt% HCl for 6h.

Characterization
Powder X-ray diffraction data was obtained by a D/max-2200/PC (Rigaku, Japan) with Cu Kα radiation at 3 KW at a scan rate of 2° min$^{-1}$. A ZESS scanning electron microscope (SEM) was used to investigate the morphology. The micro morphology and lattice fringes were observed by a TEM. An TGA/SDTA851 (METTLER TOLEDO, China). Thermogravimetric analyzer (TGA) was used to observe the pyrolysis process with a heating rate of 10 °C min$^{-1}$ from 20 °C to 800 °C in the air. The X-ray photoelectron spectroscopy (XPS) data was provided by a Nexsa (Thermo Fisher, America).

Electrochemical Measurement
The electrode sheet is prepared by the following method: The test sample was mixed with conductive agent and the binder in the NMP at a mass ratio of 8:1:1, then the uniform slurry was spreaded on the copper foil with a 150 μm preparer and dried for 8 h at 80 °C. Finally, the copper foil coated was cut into small discs with a diameter of 12 mm through a microtome. The coin cells were assembled in a glovebox (MBRAUN, Germany) filled with Ar gas, and using Li-metal as counter electrode, 1
M LiPF$_6$ in EC:EMC:DMC (1:1:1 in volume) as electrolyte, and polypropylene foil as the separator. The cycling, rating and GITT data of the cells were collected by a Land workstation (CT2001A, LAND, China). The CVs and EIS measurements were tested by an electrochemical analyzer (CHI760, China).
Fig S1. Growth mechanism for CNTs.

Fig S2. XRD diffraction patterns of Fe₃C@C.
Fig S3. SEM image of Fe$_3$C@C

Fig S4. The CV curves of Fe$_2$O$_3$ and Fe$_2$O$_3$-Fe$_3$C@C.
Fig S5. Schematic illustration of the internal E-field for the Fe$_2$O$_3$-Fe$_3$C@C heterostructure.