Electronic Supplementary Information

Graphene-Based Nanostructure with Expanded Ion Transport Channels for High Rate Li-ion Battery

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1. Sample preparation

The preparation process for the samples can be described as follows:

1) 300 mg Graphite oxide (GO), which was prepared by modified Hummers method,[1] was added into deionized water (300 mL) and sonicated with a high power ultra-sonication device (JY92-N, China, 300 W) for 1 h to obtain GO suspension;

2) 30 mg organic carbon source (glucose, sucrose or polyvinyl alcohol (PVA)) was dissolved in 50 mL deionized water at 353 K with continuous stirring for 5 h, and then the above solutions were slowly introduced into the GO suspensions with stirring in 15 minutes;

3) The above mixtures were heated in a thermostat water bath at 353 K, and after the water in the suspensions was evaporated out, small pieces of film-like samples were formed. Then the obtained dry samples were thermally treated in N_2 atmosphere at 1173 K for 4 h, and finally the graphene-based materials were fabricated, which were denoted as PGN (PVA case), GGN (glucose case) and SGN (sucrose case). Note that PGN, GGN and SGN are still in the form of small pieces of films which are characterized by layered structure proved by SEM characterization.

2. Sample characterization

(1) Structure characterization:

XRD measurements were conducted at room temperature using a specular reflection mode (Bruker D-8, Cu Kα radiation, λ=0.154056 nm). SEM and TEM observations were performed using Hitachi S-4800 (Hitachi, Japan) and JEOL 2100F (JEOL, Japan) respectively. Nitrogen cryo-adsorption was measured by using BEL mini-instrument, and the specific surface area was obtained by Brunauer-Emmett-Teller (BET) analyses of the adsorption isotherm, which is abbreviated as S_{BET}, and the test results show that the S_{BET} of PGN is 254.72 $m^2 \cdot g^{-1}$, which is higher than that of SGN (S_{BET} : 207.15 $m^2 \cdot g^{-1}$) and GGN (S_{BET} :194.83 $m^2 \cdot g^{-1}$).

(2) Electrochemical performance measurement:

Assembly of the test cells: PGN, SGN, GGN, graphene and graphite which is the raw materials of the graphene and graphene-based materials in this paper, were tested as the active materials. Firstly, the active materials were ground into fine powders, and 90 wt % active materials, 5 wt % Super P and 5 wt % PTFE were well mixed in ethanol solution to make uniform mixture slurry under sonication. Then, the mixture slurry was spread uniformly on nickel foam and dried at 393 K overnight under vacuum. Finally, coin cells (CR2032) were assembled in Ar filled glove box and the lithium foils were used as the anode, 1 M $LiPF_6$ mixture solution (1:1 (v/v) of ethylene carbonate (EC) and dimethyl carbonate (DMC)) as the electrolyte. Note even after grounding, the microstructure (loosely or tightly stacking structure) is kept for each sample by SEM observations.

Electrochemical test: The coin cells were tested at room temperature using battery tester (Lixing, China) and electrochemistry workstation (Gamry Instrument, USA). The current of the first five charge/discharge cycles (formation process) was maintained at 20 $mA \cdot g^{-1}$ until the voltage dropped to 0.005 V, and then the Li^+ were deintercalated at 20 $mA \cdot g^{-1}$ until it reached 2.5 V. After the above formation process, the cells were measured under various charge/discharge current densities from 500 $mA \cdot g^{-1}$ to 5 $A \cdot g^{-1}$ between 0.005 and 2.5 V. Note that the charge and discharge processes were conducted at the same current density.

References

(1) W. S. Jr. Hummers and R. E. Offeman, *J. Am. Chem. Soc.*, 1958, **80**, 1339.