

Supporting information

Engineering Nanostructured Electrode Materials for High Performance Sodium Ion

Batteries: Case Study of 3D Porous Interconnected WS₂/C Nanocomposite

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Experimental section

Synthesis: COOH-functionalized multiwalled carbon nanotube (CNT) (1.8 mg, Aldrich) and single layer graphene oxide (GO) (9 mg, Cheaptubes, USA) were added to solvent of 1,2-propanediol (30 ml, Aldrich) and dispersed by stirring and sonication to form homogeneous GO-CNT solution. Afterwards, (NH₄)₂WS₄ (0.051 g, Aldrich) was put into the above GO-CNT solution and stirred overnight to get the resultant precursor solution, which was poured into a syringe connected to a metal nozzle of 1.6 mm diameter. The flow rate was *ca.* 30 μl/min. The distance between the substrate and nozzle was 4 cm. Ti foil is used as substrates and current collector as well. The substrate was preheated to 238 °C before the deposition. The precursor solution was sprayed onto the substrate by applying a high voltage of 12 kV. The as-prepared WS₂/C nanocomposites were annealed in a tube furnace at first at 450 °C for 2 hours under H₂ (5 vol%)/Ar (95 vol%) atmosphere, and then 600 °C for 2 hours under Ar.

Structural and electrochemical characterization: XRD measurements were performed with a Philips PW 3020 diffractometer using Cu-K α radiation. SEM was carried out using a JEOL 6300F field-emission scanning electron microscopy (JEOL, Tokyo, Japan) operated at 15 keV. TEM and HRTEM were performed by using a JEOL 4000FX transmission electron microscope (JEOL, Tokyo, Japan) operated at 400 kV.

Electrochemical test: WS₂/C nanocomposites grown on the Ti current collector used as working electrode are directly tested without binder or any conductive additives in an electrochemical test cells (Swagelok-type), which were assembled in an argon-filled glove box (O₂ \leq 0.1 ppm, H₂O \leq 3 ppm). Sodium metal is used as the counter/reference electrode, and 1 M solution of NaClO₄ in the propylene carbonate (PC) with 5% fluoroethylene carbonate (FEC) as the electrolyte. Glass fiber (Whatman) is used as separator. The Na batteries were discharged and charged galvanostatically in the fixed voltage window between 0.01 V to 3 V on an Arbin MSTAT battery tester at room temperature. Cyclic voltammetry was tested by Voltalab 80 electrochemical workstation at scan rate of 0.1 mV/s.

Figures and captions

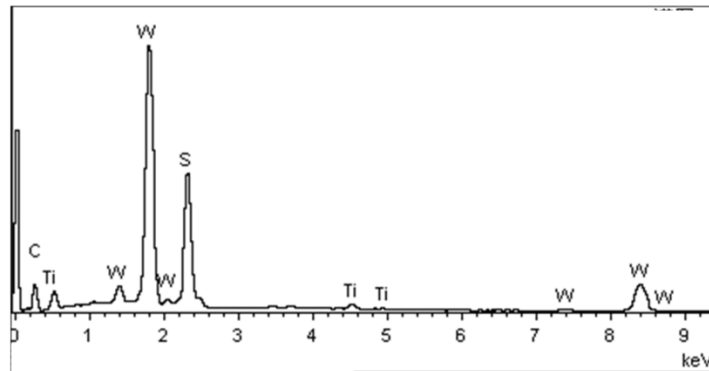


Figure S1. EDX spectra of carbon coated 3D porous interconnected WS₂/C nanocomposite.

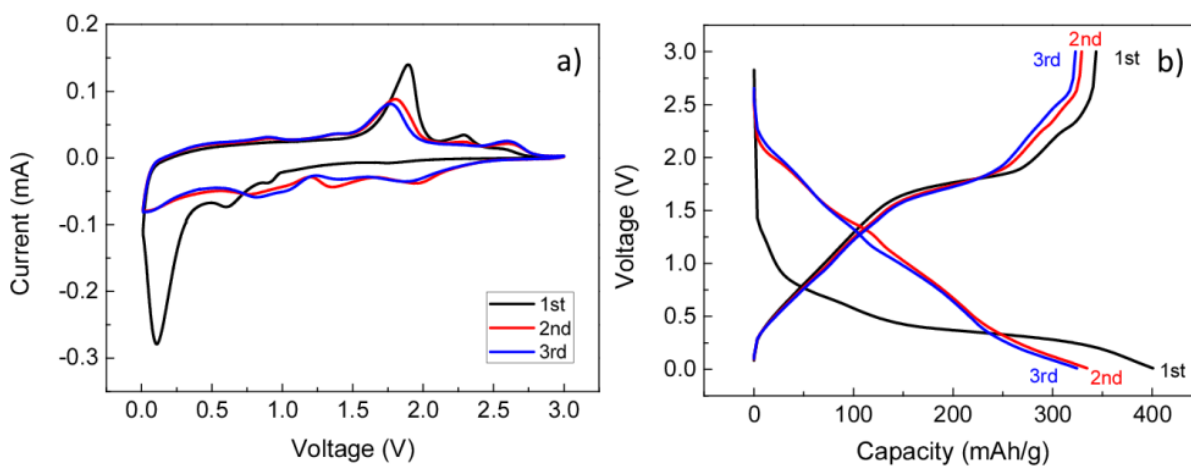


Figure S2. a) Cyclic voltammograms of pure WS₂ without rGO and CNT at scan rate of 0.1 mV/s. b) Charge and discharge voltage profiles for the first three cycles for sodium storage for pure WS₂ without rGO and CNT.

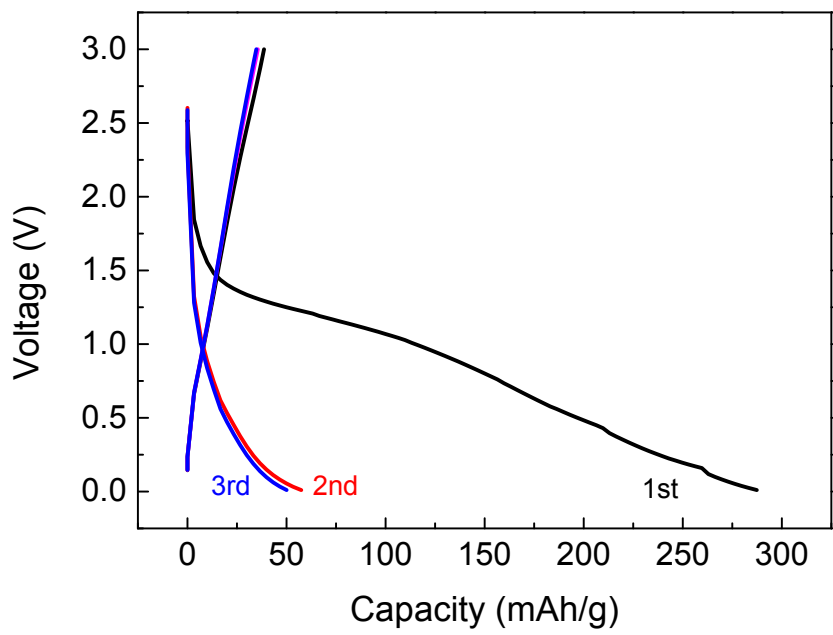


Figure S3. Charge and discharge voltage profiles for the first three cycles for sodium storage for pure rGO and CNT carbon composite without WS₂.