Electronic Supplementary Material (ESI) for RSC Advances.

Electronic Supplementary Information

Improve electrochemical performance of rechargeable lithium-selenium batteries by inserting a free-standing carbon interlayer

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Experimental

1.1 Preparation and characterization of carbon interlayer and selenium electrode

For preparation the carbon interlayer, cellulose based filter papers (model 102, Hangzhou Whatman-Xinhua Filter Paper Co., Ltd) with a diameter of 9.0 cm commonly used in laboratory were carbonized in a tube furnace with temperature rising from room temperature to 800 ℃ at a rate of 5 ℃ min^{-1} and the temperature was kept at 800 ℃ for 2 h with the presence of Ar flow of 100 mL min^{-1}. Raman spectra of the dried sample were collected with LABRAM-HR 800 in the range of 2000-1000 cm^{-1} with He-Ne laser excitation at 532 nm. Thermogravimetric analysis (TGA, SDTQ600) was conducted to monitor the pyrolysis process of cellulose based filter papers. N_2 adsorption/desorption measurements were performed by using Quantachrome instrument (Quabrasorb SI-3MP) at 77 K.

Considering that nanosized TiO_2 is used as an adsorbent for polysulfides in lithium-sulfur battery, we choose Se/TiO_2 composite as cathode material. To obtain selenium-TiO_2 composite based on our previous research work [1], a mixture of selenium and TiO_2 in the weight ratio of 7 : 3 was heated in a tubular furnace under flowing argon atmosphere at 260 ℃ for 12 h.

The selenium electrode was prepared by pressing a powder mixture of Se/TiO_2 composite, carbon black (Super P Timcal), and sodium alginate (SA) in a weight ratio of 80:10:10 onto an aluminum foil. After drying under vacuum at 70 ℃ for 24 h, the foil was cut into pellets, and the selenium loading density was 1.6 mg cm^{-2}.

1.2 Cell assembly and characterization

CR2032 coin cells consisting of a metallic lithium anode, a Celgard separator, and the Se/TiO_2 cathode were assembled in an argon-filled glovebox with the insertion of a carbon interlayer between the selenium electrode and the Celgard separator. The electrolyte used was 1.5 mol L^{-1} lithium lithium bis(trifluoromethane sulfonyl)imide (LiTFSI, 99.95%, Aldrich) in a solvent mixture of 1,3-dioxolane and 1,2-dimethoxyethane (1:1, v/v) as the electrolyte.

Cyclic voltammetry (CV) and electrochemical impedance spectroscopy measurements were conducted using Solartron 1470E cell test. The cyclic voltammograms (CV) and the electrochemical impedance spectroscopy (EIS) of the working electrode were carried out in three-electrode system and the Se/TiO_2 cathode was used as the working electrode, metallic lithium was used as the reference electrode and the counter electrode. CV tests were performed at a scan rate of 0.2 mV s^{-1} in the potential range of 1.0 to 3.0 V. AC impedance measurements were carried out at open-circuit potential in the frequency range between 100 kHz and 10 mHz with a perturbation amplitude of 5 mV. The galvanostatic charge/discharge tests were carried out in the potential range of 1.2 to 3.0 V under a LAND CT2001A charge-discharge system. All experiments were conducted at room temperature. The morphologies of the carbon interlayer were observed with a scanning electron microscopy (FEI Quanta-200) and a scanning transmission electron microscopy (FEI Tecnai G2 F20).

References:

[1] Q. Li, Z. Zhang, K. Zhang, L. Xu, J. Fang, Y. Lai, J. Li, J. Solid State Electrochem., 2013, 17, 2959.

Supporting figure

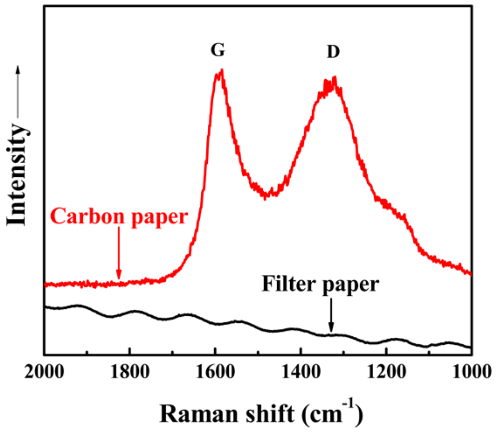

Fig. S1 Raman of the carbon interlayer and the cellulose based filter papers

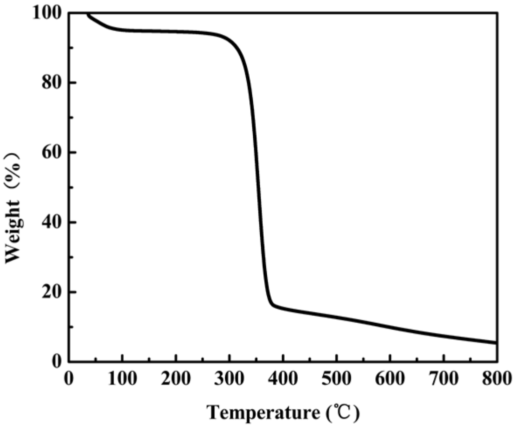

Fig. S2 TGA of the cellulose based filter papers

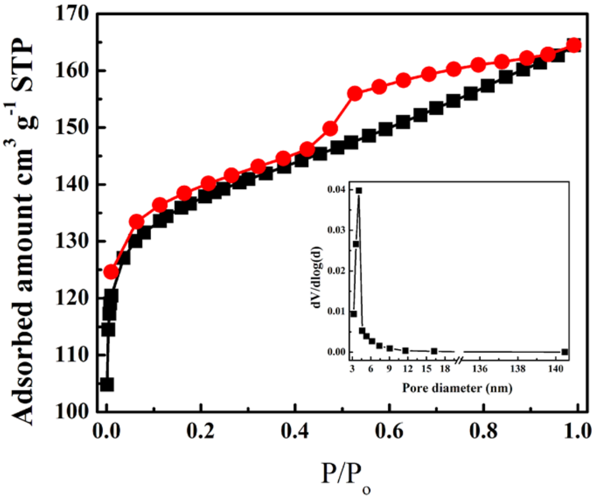

Fig. S3 N_2 absorption-desorption isotherm and pore distribution (inset) of the carbon interlayer

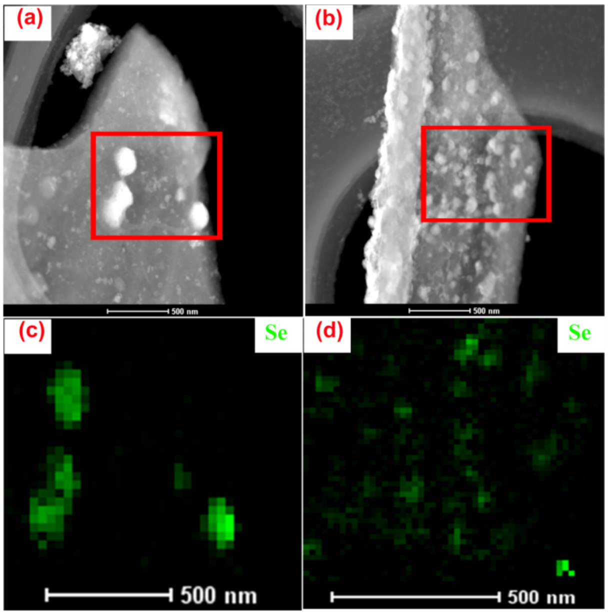

Fig. S4 TEM image of the cycled carbon interlayer (a) (b), (c) (d) elemental mapping of (a) (b), respectively