Electronic Supplementary Material

Multi-effect anthraquinone-based polyimide enclosed SnO_2/reduced graphene oxide composite as high-performance anode for lithium-ion battery

Lin Wang[1] , Yinjie Kuang (✉)[1] , Qian Cui[1] , Junyu Shi[1] , Liubin Song (✉)[1] , Qionghua Li[1] , Tianjian Peng[2]

1 Hunan Provincial Key Laboratory of Materials Protection for Electric Power and Transportation, School of Chemistry and Chemical Engineering, Changsha University of Science and Technology, Changsha 410114, China

2 Guizhou Dalong Huicheng New Material Co., Ltd, Tongren 554000, China

E-mails: kuangyinjie1973@163.com (Kuang Y.); liubinsong1981@126.com (Song L.)

Experimental Section

Preparation of GO

Graphite powder was ultrasonically dispersed in 150 mL of concentrated sulfuric acid (98 %) and mechanically stirred in an ice-water bath at low temperature (< 4 °C) while 50 g of potassium permanganate was slowly added in three times, 15 g for the first two times, 20 g for the last time, with an interval of 12 h to ensure adequate reaction. After all potassium permanganate was added, the mixture was heated to 35 °C for 12 h. Then 150 mL of deionized water was added into the slurry mixture. Subsequently, 25 mL of hydrogen peroxide (30 %) was added drop by drop. The solution was centrifuged after standing for 6 hours, and washed three times with hydrochloric acid (10 wt%) and deionized water, respectively. After washing, the solution was placed in a dialysis bag with a cut-off molecular weight of 8000-14000 and left for 7 days until the pH was close to 7. Finally, the fluffy graphene oxide sponge was obtained by freeze-drying at -60 °C for 24 hours.

Preparation of SnO_2

7.7 g of $SnCl_2 \cdot 2H_2O$ was dissolved in 28 mL of hydrochloric acid (37 %), heated to 60 °C and maintained for 5 min, then cooled down to the room temperature, added 250 mL of anhydrous ethanol and then ammonia solution (25 %) was added drop by drop slowly until the pH at 8.0. The solution was centrifuged after standing for 2 hours, and washed three times with deionized water and anhydrous ethanol respectively. After washing, the yellowish nano SnO_2 powders were obtained by drying at 60 °C for 4 h and annealing at 400 °C for 3 h in a muffle furnace finally.

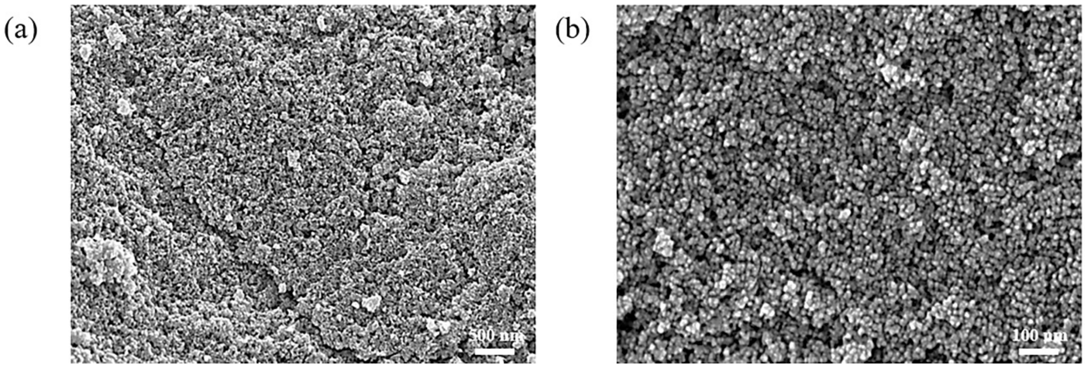

Fig. S1 The different magnification SEM images of SnO_2.

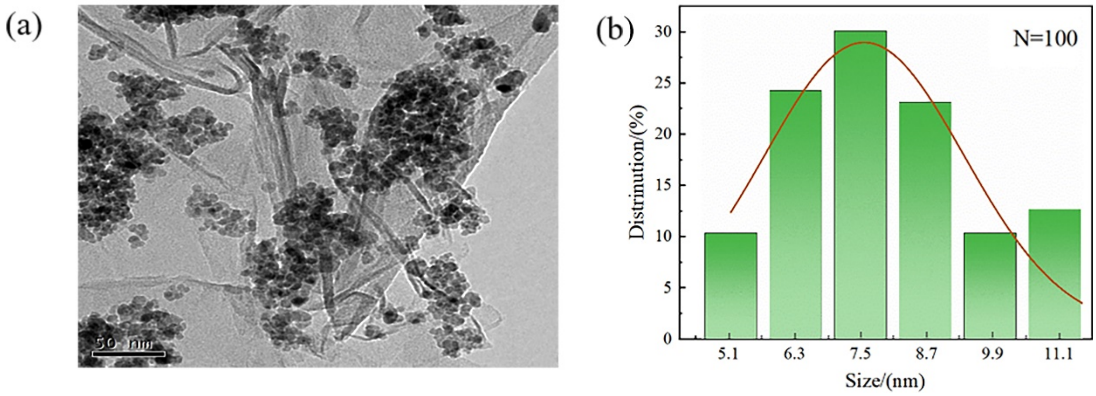

Fig. S2 (a) TEM image of layer-by-layer assembly of SnO_2@BPAQ/rGO and (b) particle size distribution image.

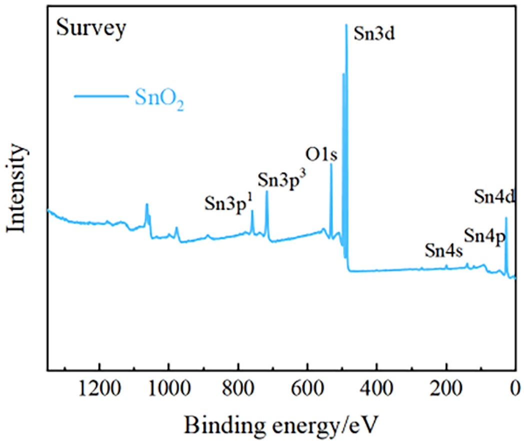

Fig. S3 XPS survey spectrum of SnO_2.

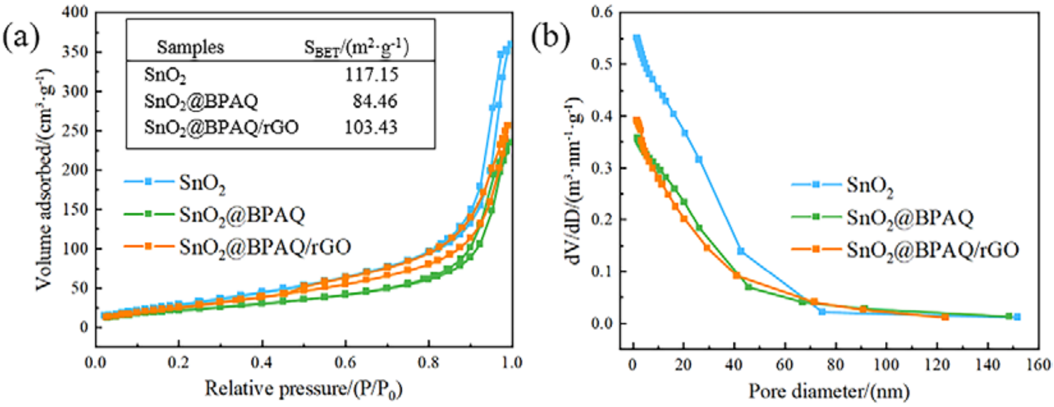

Fig. S4 (a) Nitrogen adsorption/desorption isotherms of bare SnO_2, SnO_2@BPAQ, and SnO_2@BPAQ/rGO; (b) Pore size distribution of bare SnO_2, SnO_2@BPAQ, and SnO_2@BPAQ/rGO.

The theoretical specific capacity of the three electrodes is calculated by Eq. S5

$$C_{(mAh\cdot g^{-1})}=\frac{nF}{3.6M_w}$$

where C represents the theoretical capacity, n is the theoretical electron transfer number, F represents the Faraday constant (96485 $C\cdot mol^{-1}$), and M_w is the relative molecular mass of the structural unit. If the conversion reaction and alloying reaction are completely reversible during the charging and discharging process of tin dioxide, the theoretical specific capacities of the three electrodes are:

C(SnO_2) =1494 $mAh\cdot g^{-1}$

C(SnO_2@BPAQ) =1282 $mAh\cdot g^{-1}$

C(SnO_2@BPAQ/rGO) =1232 $mAh\cdot g^{-1}$

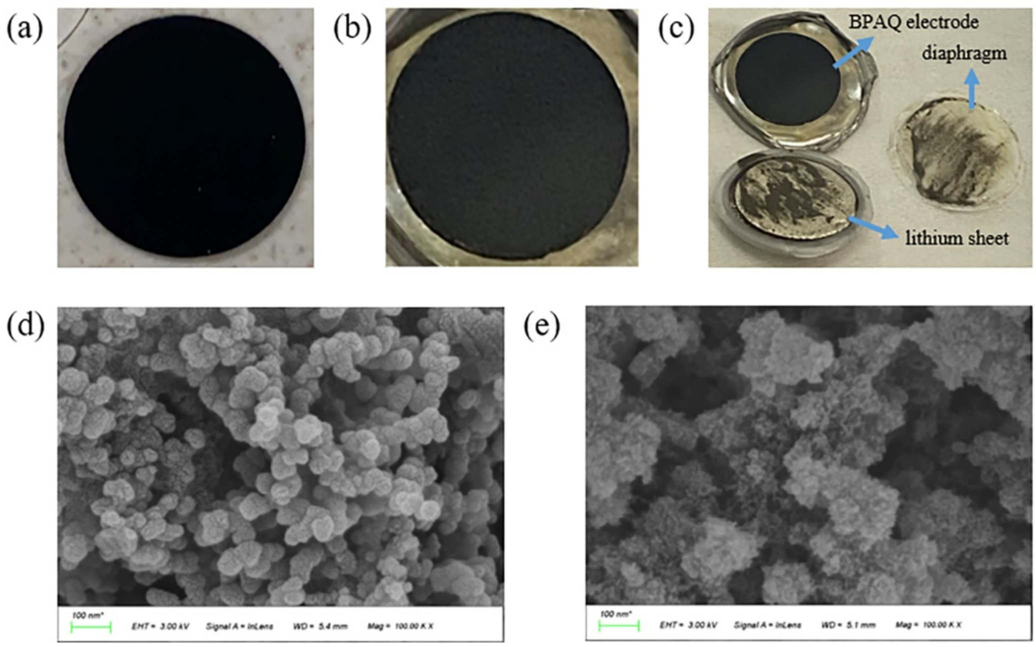

Fig. S5 Photos of BPAQ electrode before cycling (a) and after 200 cycles at 0.25 $A\cdot g^{-1}$ (b); Disassembled BPAQ button cell after 200 cycles at 0.25 $A\cdot g^{-1}$ (c); SEM images of BPAQ electrode before cycling (d) and after 200 cycles at 0.25 $A\cdot g^{-1}$ (e)