Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.
This journal is © The Royal Society of Chemistry 2015

Stannous ions reducing graphene oxide at room temperature to produce SnO_x-porous carbon nanofiber mats as binder-free anodes for lithium-ion batteries

Feilong Yan,[a] Xuan Tang,[a] Yuehua Wei,[a] Libao Chen,[b] Guozhong Cao,[c,d,*] Ming Zhang,[a,**] Taihong Wang[a]

[a] *Key Laboratory for Micro-Nano Optoelectronic Devices of Ministry of Education, School of Physics and Microelectronics, State Key Laboratory for Chemo/Biosensing and Chemometrics, Hunan University,Changsha, 410082, P.R. China. E-mail: zhangming@hnu.edu.cn*

[b] *State Key Laboratory for Power Metallurgy, Central South University, Changsha,410083, P.R. China.*

[c] *Department of Materials Science & Engineering, University of Washington, Seattle, Washington, 98195, USA. E-mail: gzcao@uw.edu*

[d] *Beijing Institute of Nanoenergy and Nanosystems, Chinese Academy of Sciences, Beijing 100083, China.*

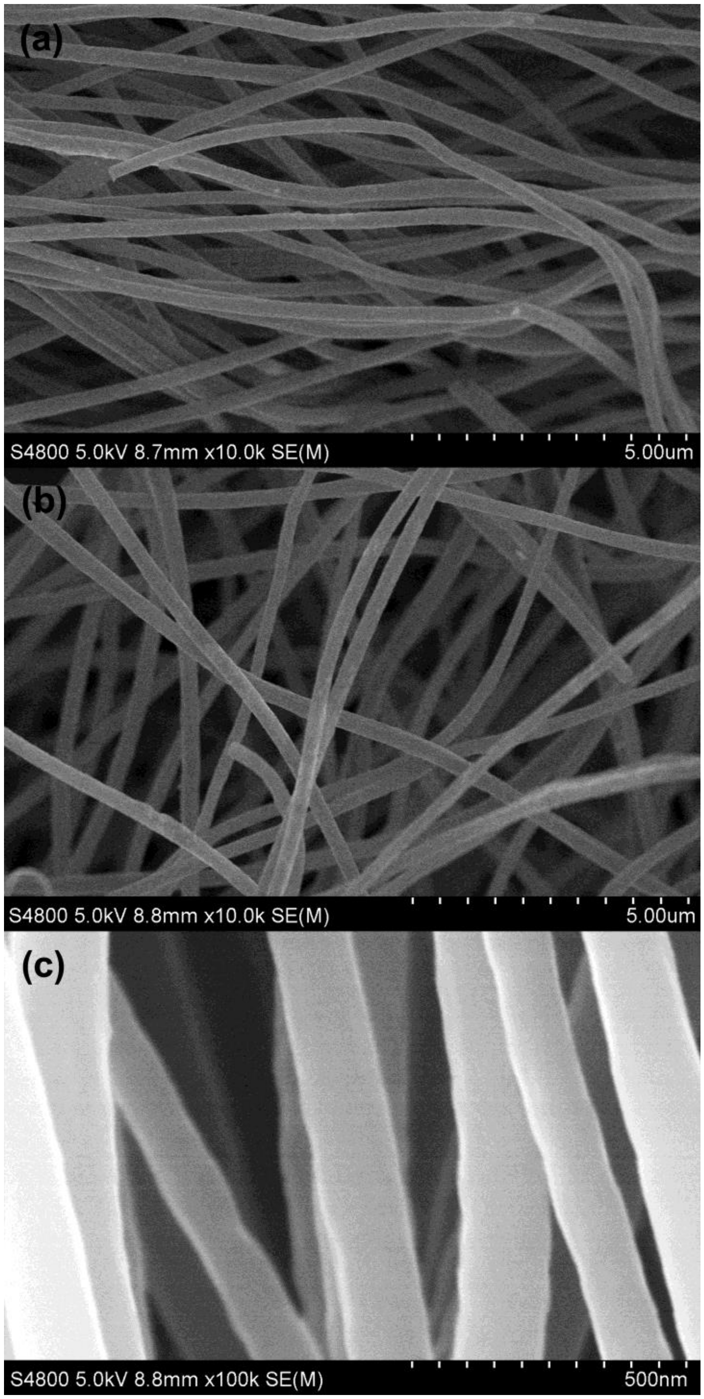

Figure S1 (a) SEM images of as-prepared SGCF; (b) SEM images of the SGCF-230 mat, treated at 230℃ in air. SEM images of as-prepared SGCFs and SGCF-230 composites are shown without any obvious formation of nanoparticles; (c) high-magnification SEM image of SCF-700 mats.

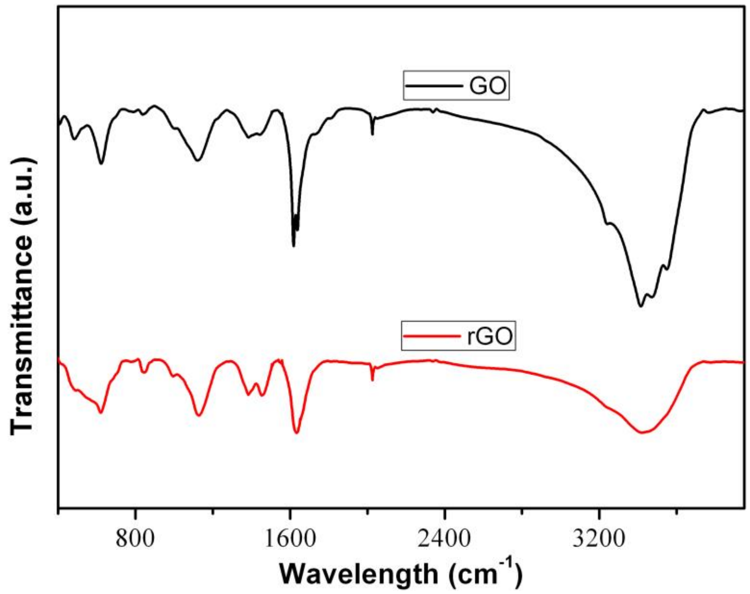

Figure S2 FT-IR spectra for rGO and GO.

The FT-IR spectra of GO confirmed the presence of oxygen-containing groups, such as C–OH ($\nu_{C–OH}$ at 3420 cm^{-1}), C–O–C ($\nu_{C–O–C}$ at 1220 cm^{-1}), and C=O in carboxylic acid moieties ($\nu_{C=O}$ at 1730 cm^{-1}). Other characteristic vibrations were the O–H deformation peak at 1400 cm^{-1}. The peak at 1620 cm^{-1} was assigned to the contributions from the skeletal vibrations of the graphitic domains. For the rGO, the carboxylic acid vibration band ($\nu_{C=O}$ at 1730 cm^{-1}) disappeared. A weak signal for the C–OH stretching vibration at 3420 cm^{-1} could be ascribed to the vibrations of the adsorbed water molecules. So it could be concluded that GO was reduced by the stannous ions.[1, 2]

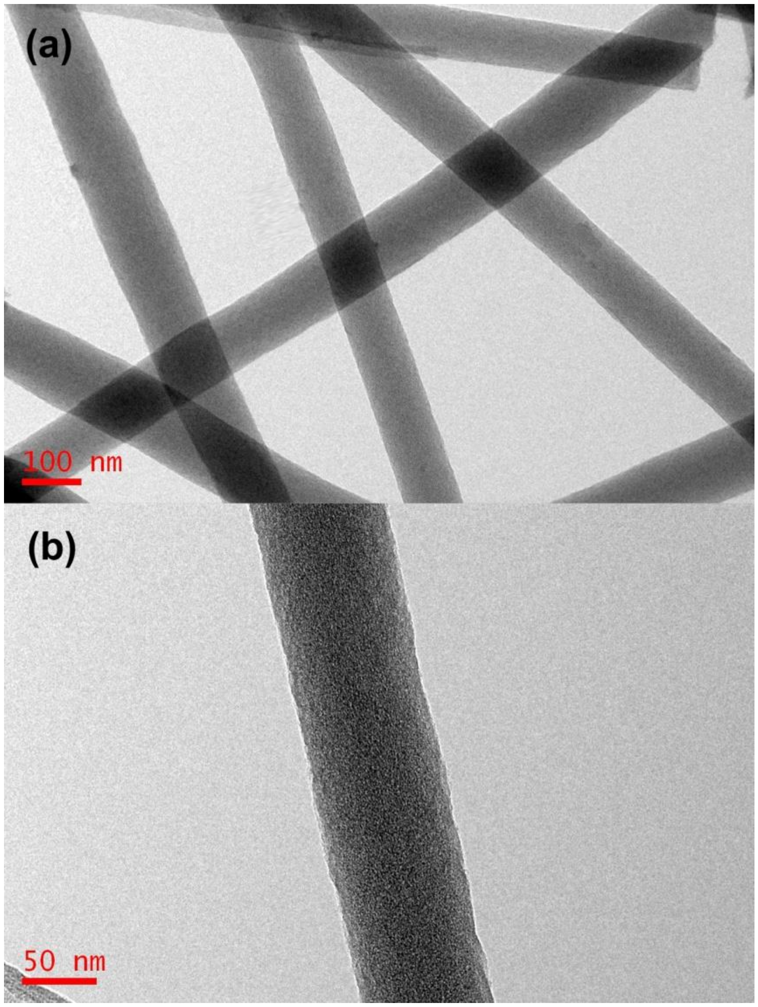

Figure S3 (a) Low and (b) high magnification TEM images of the SGCF-700. It is clear that porous carbon nanofibers are well-distributed and slippy (Figure S2a). Furthermore, there seems to be some SnO_x nanoparticles being uniform density distribution on the surface in Figure SI2b.

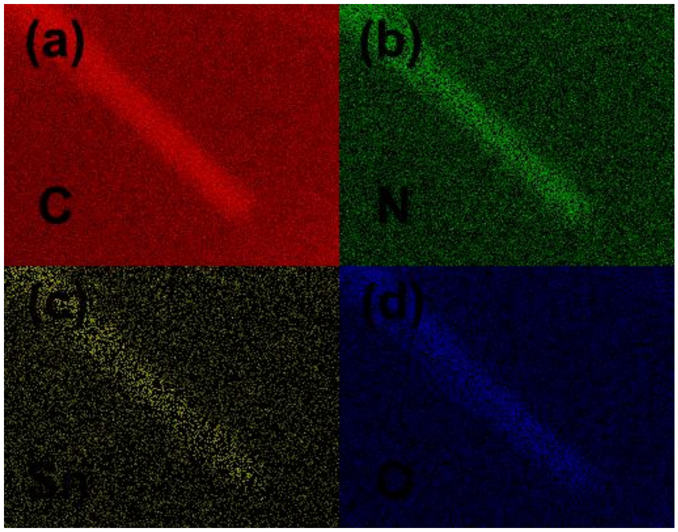

Figure S4 (a-d) Elemental mapping images showing the homogenous distribution of all four elements of C, N, Sn and O in carbon nanofibers.

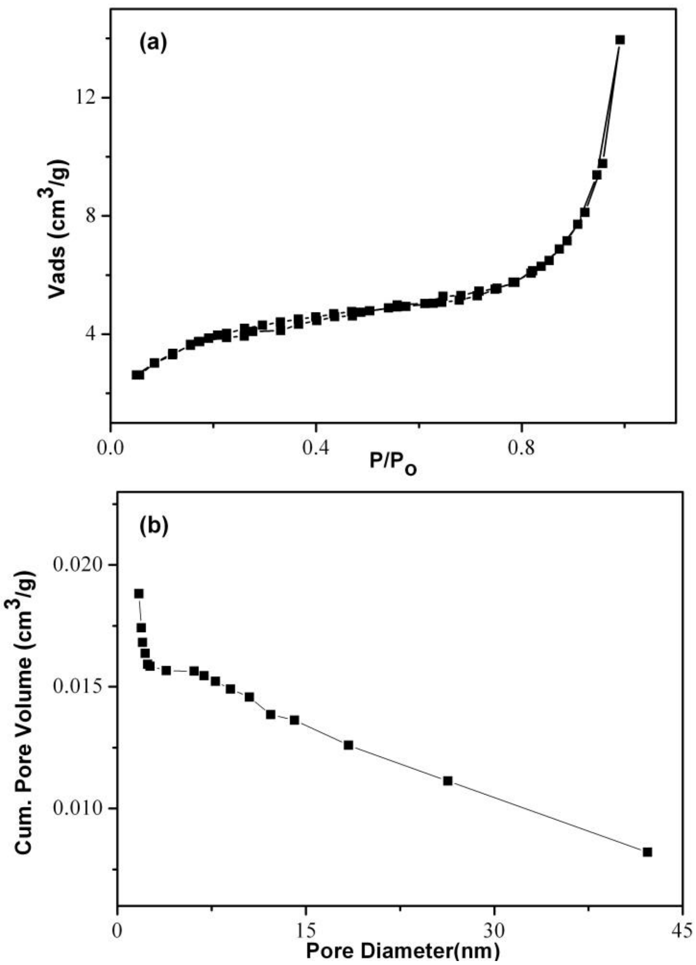

Figure S5 Nitrogen adsorption and desorption isotherms (a) and pore size distributions (b) of the the SGCF-700.

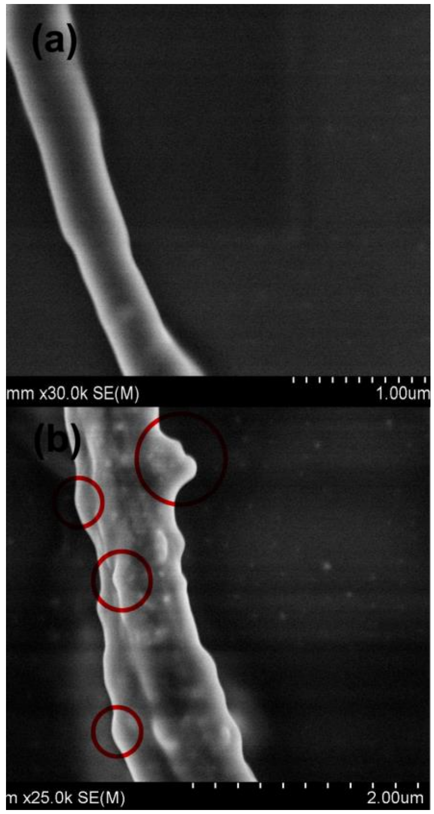

Figure S5 (a) high-magnification SEM image of SGCF-700 after 1000 cycles, (b) and SCF-700 after 100 cycles.

The amount of SnO and SnO_2 was easily by TGA. The weight ratio can be estimated to be 18.5wt% for SnO and 13.1wt% for SnO_2. However, the remaining weight of the stabilized electrospun PAN nanofibers and graphene at 700 ℃ in inert gases was 50% and 80%, respectively.[3, 4] The precursor solution was 6115 mg and GO was 0.6 mg, so the carton nanofiber was 3057.5 mg and rGO was 0.206 mg at 700 ℃ in inert gases. At last, we can approximatively calculate the amount of CNF, graphene, SnO, and SnO_2 was 67.3wt%, 0.1wt%, 18.5wt% and 13.1wt%, respectively.

The calculation method to estimate the weight ratios of SnO and SnO_2 in SGCF-700

The weight ratio of SnO:

$$\begin{aligned} \text{SnOwt\%} &= (\text{weight}-\text{residue})\times \text{SnOatom\%}\times\frac{M_{SnO}}{M_{SnO2}} \\ &= 33.8\text{wt\%}\times 61.3\%\times\frac{134.7}{150.7} \\ &= 18.5\text{wt\%} \end{aligned}$$

The weight ratio of SnO_2:

$$\begin{aligned} \text{SnO}_2\text{wt\%} &= (\text{weight}-\text{residue})\times \text{SnO}_2\text{atom\%} \\ &= 33.8\text{wt\%}\times 38.7\% \\ &= 13.1\text{wt\%} \end{aligned}$$

The calculation method to estimate the weight ratios of CNF and graphene in SGCF-700 is shown as follow.

The weight of rGO:

$$m_{rGO} = m_{GO}\times\frac{M_{rGO}}{M_{GO}}\times 80\%$$

$$= 0.4 \times 1.5 \times \frac{12}{28} \times 80\%$$
$$= 0.206mg$$

The weight ratio of CNF:

$$CNFwt\% = \frac{(DMF+PAN) \times 50\%}{(DMF+PAN) \times 50\% + m_{rGO}} \times 67.4\%$$

$$= \frac{(5685+430) \times 50\%}{(5685+430) \times 50\% + 0.2} \times 67.4\%$$
$$= 67.3\%$$

Reference

1. M. Zhang, D. Lei, Z. Du, X. Yin, L. Chen, Q. Li, Y. Wang and T. Wang, *Journal of Materials Chemistry*, 2011, **21**, 1673-1676.
2. B. Zhao, G. Zhang, J. Song, Y. Jiang, H. Zhuang, P. Liu and T. Fang, *Electrochimica Acta*, 2011, **56**, 7340-7346.
3. Z. Zhou, K. Liu, C. Lai, L. Zhang, J. Li, H. Hou, D. H. Reneker and H. Fong, *Polymer*, 2010, **51**, 2360-2367.
4. J. Shen, Y. Hu, C. Li, C. Qin and M. Ye, *Small*, 2009, **5**, 82-85.