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

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Figure S1 (a) SEM images of as-prepared SGCF; (b) SEM images of the SGCF-230 mat, treated at 230°C 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 ($\nu_{\text{C-OH}}$ at 3420 cm$^{-1}$), C–O–C ($\nu_{\text{C-O-C}}$ at 1220 cm$^{-1}$), and C=O in carboxylic acid moieties ($\nu_{\text{C=O}}$ 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 ($\nu_{\text{C=O}}$ 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 S12b.
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 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 °C in inert gases was 50% and 80%, respectively. 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 °C 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:

\[
\text{SnOwt}\% = (\text{weight}-\text{residue}) \times \text{SnOatom}\% \times \frac{M_{\text{SnO}}}{M_{\text{SnO}_2}}
\]

\[
= 33.8\text{wt}\% \times 61.3\% \times \frac{134.7}{150.7}
\]

\[
= 18.5\text{wt}\%
\]

The weight ratio of SnO$_2$:

\[
\text{SnO}_2\text{wt}\% = (\text{weight}-\text{residue}) \times \text{SnO}_2\text{atom}\%
\]

\[
= 33.8\text{wt}\% \times 38.7\%
\]

\[
= 13.1\text{wt}\%
\]

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

The weight of rGO:

\[
m_{\text{rGO}} = m_{\text{GO}} \times \frac{M_{\text{GO}}}{M_{\text{GO}}} \times 80\%
\]
\[
= 0.4 \times 1.5 \times \frac{12}{28} \times 80% \\
= 0.206 \text{mg}
\]

The weight ratio of CNF:

\[
\text{CNFwt\%} = \frac{(\text{DMF+PAN}) \times 50\%}{(\text{DMF+PAN}) \times 50\% + \text{m}_{\text{rGO}}} \times 67.4\% \\
= \frac{(5685+430) \times 50\%}{(5685+430) \times 50\% + 0.2} \times 67.4\% \\
= 67.3\%
\]

Reference