Supporting Information for
Self-assembled MoS$_2$-carbon nanostructures: influence of nanostructuring and carbon on lithium battery performance
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Experimental details

Synthesis of MoS$_2$-carbon: The MoS$_2$-carbon composites with varying carbon weight fractions were synthesized by a hydrothermal method. Resorcinol/formaldehyde (Sigma-Aldrich) and ammonium tetrathiomolybdate (Sigma-Aldrich) were used respectively as carbon and MoS$_2$ precursors. A desired concentration (0.076 M) of aqueous solution of ammonium tetrathiomolybdate was added to another aqueous solution containing resorcinol, formaldehyde and sodium carbonate under continuous stirring. The ratios of resorcinol to formaldehyde and to sodium carbonate were kept at 0.185 g ml$^{-1}$ and 251 respectively calculated on a molar basis for all MoS$_2$-carbon composites. However, the concentrations of resorcinol, formaldehyde and sodium carbonate were varied to obtain various carbon loadings in the final product. The intense violet color sol was transferred to a Teflon-lined stainless steel autoclave of capacity 100 ml (70% filling) and heated at 180 °C for 12 h and then cooled to room temperature. The resultant black product was recovered by centrifugation and washed with deionized water and freeze dried. The dried product was further calcined at 550 °C for 4 h in an atmosphere of 5% H$_2$ balanced with Ar at a heating rate of 5 °C min$^{-1}$. Pure MoS$_2$ was synthesized by hydrothermal treatment of ammonium tetrathiomolybdate (180 °C for 12 h, calcination at 550 °C for 4 h under H$_2$/Ar), but without any addition of resorcinol and formaldehyde. The materials were designated as MS-0, MS-11, MS-22, MS-32 and MS-41 corresponding to 0, 11, 22, 32 and 41 wt % of carbon in the MoS$_2$-carbon composites.

Characterizations: The crystallographic phase identification was performed using powder x-ray diffraction (Scintag theta–theta PAD-X-ray Diffractometer; Cu-K$_\alpha$ radiation, $\lambda = 1.5406$ Å). The morphology was observed by scanning electron microscopy (SEM, LEO...
and transmission electron microscopy (TEM, FEI Tecnai G2 T12). Specific surface area (BET) was obtained from nitrogen adsorption-desorption isotherms (Micromeritics ASAP 2020). Estimation of carbon content in MoS$_2$-carbon composites was done using thermogravimetric analysis (TGA, TA Instruments Q5000). TGA experiments were performed by heating the sample in air from room temperature to 700 °C at a heating rate of 10 °C min$^{-1}$. For the working electrode, slurry of the active material and carbon black (Super P Timacal) was prepared with PVdF (Sigma) in a weight ratio of MoS$_2$:CB:PVdF = 90:0:10, 80:10:10, 65:10:10, 40:50:10 in N-methyl-pyrrolidone (NMP). The slurry was cast on a copper foil and dried in vacuum at 120 °C for 12 h. Room temperature cyclic voltammetry (CV, CH608 CH Instruments) and galvanostatic charge/discharge cycling (Maccor) were done in 2032 coin-type cells with pure metal Li (Aldrich) as anode, Whatman glass fibre as separator and 1M LiPF$_6$ in ethylene carbonate (EC, Aldrich) and dimethyl carbonate (DMC, Aldrich) (1:1 w/w) as an electrolyte.
Supplementary Figures

Figure S1. X-ray diffraction patterns of pure MoS\textsubscript{2} and MoS\textsubscript{2}-carbon (22 wt %) composite.
Figure S2. Thermogravimetry analysis of pure MoS$_2$, MS-11, MS-22, MS32 and MS-41.
Figure S3. (a) N₂ adsorption/desorption isotherms and (b) pore size distribution of pure MoS₂, MS-22 and MS-41.
Figure S4. Transmission electron micrographs of (a) MS-11 and (b) MS-32.
Figure S5. (a) Cycling stability of pure MS-22 with 0%, 10%, 25% and 50% carbon black in the electrode at a current rate of (a) 100 mAg\(^{-1}\); (b) at various current rates in the range of 0.4-4 Ag\(^{-1}\).
Figure S6. (a) Cycling stability of 550 °C and 700 °C calcined MoS₂-carbon (22 wt %) composite at a current rate of (a) 100 mAg⁻¹; (b) at various current rates in the range of 0.4-4 Ag⁻¹.
Figure S7. SAED patterns of (a) pure MoS$_2$ and (b) MoS$_2$-carbon (22 wt %) composite.