Electronic Supplementary Information

Free-standing compact cathodes for high volumetric and gravimetric capacity Li-S batteries

*Cheng Hu, Caroline Kirk, Joaquín Silvestre-Albero, Francisco Rodríguez-Reinoso and Mark James Biggs**

*Email - m.biggs@lboro.ac.uk

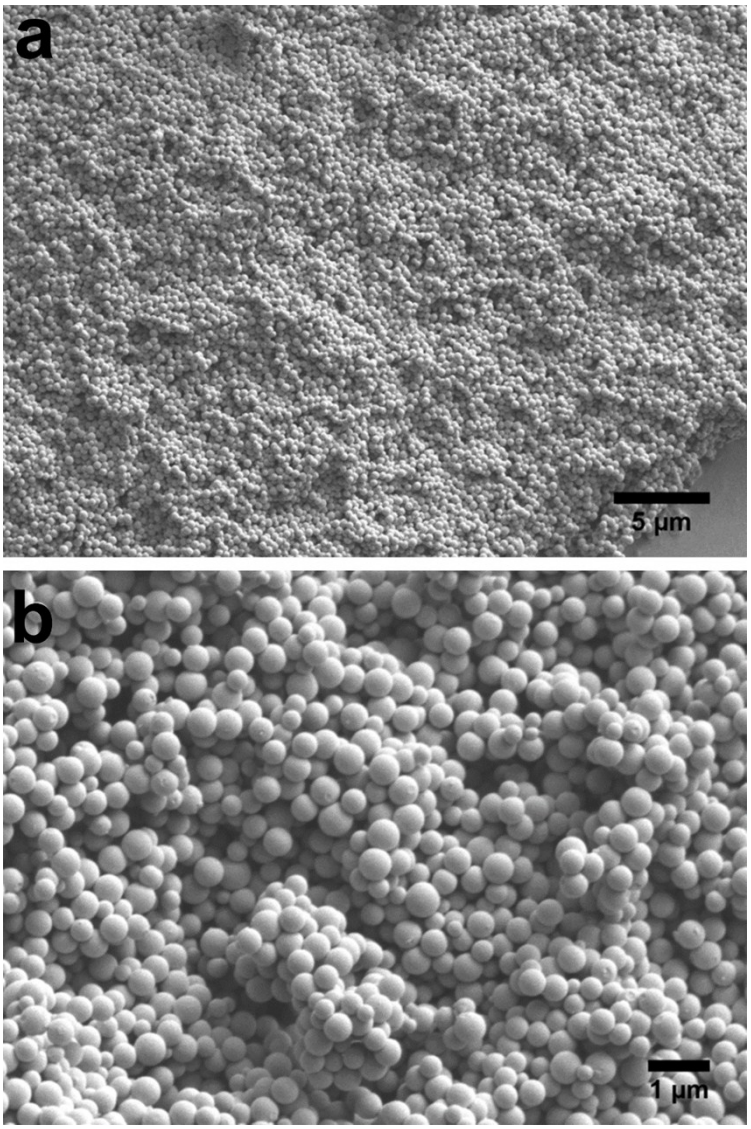

Fig. S1 SEM images of PFA-NS: (a) lower magnification; and (b) higher magnification.

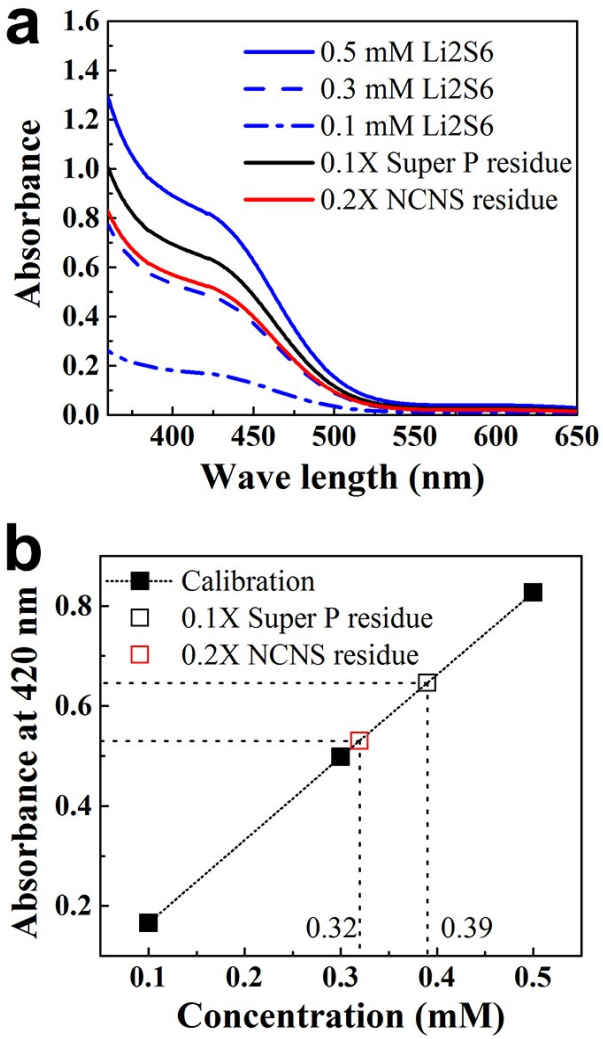

Fig. S2 (a) UV-Vis spectra of Li_2S_6 calibration solution with concentrations of 0.1, 0.3 and 0.5 mM, Super P Li_2S_6 adsorption residue solution (10 times diluted), and NCNSs Li_2S_6 adsorption residue solution (5 times diluted); (b) determination of the Li_2S_6 residue concentration after the adsorption test with Super P and NCNSs.

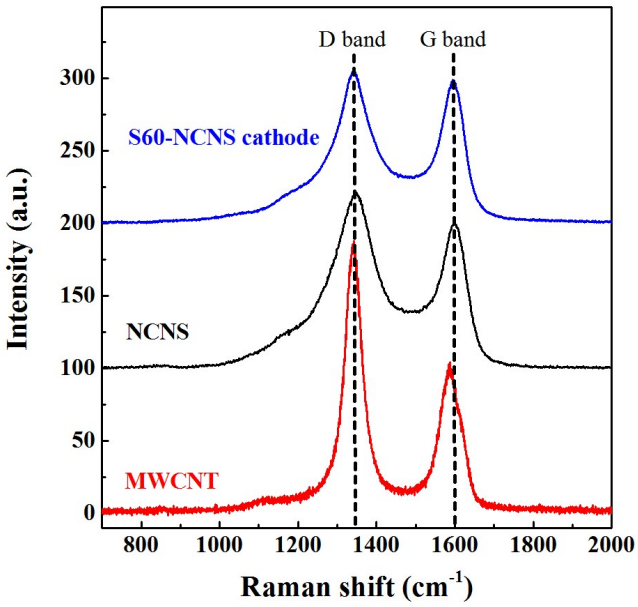

Fig. S3 Raman spectra of MWCNT and NCNS materials that are used to make the cathodes studied here, and S60-NCNS cathode itself. These were collected using a 514 nm excitation.

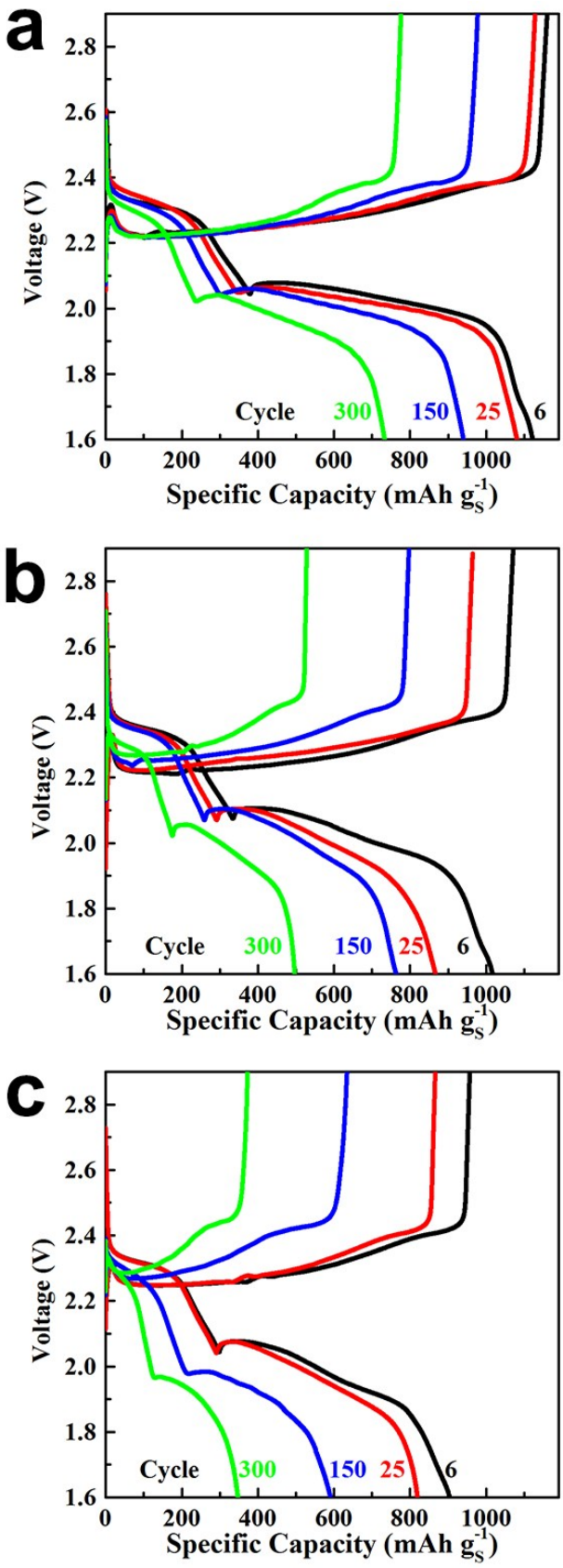

Fig. S4 0.3 C charge/discharge curves of cells containing the compact 5 mg cm^{-2} sulfur-loading S-NCNS/MWCNT cathodes at different cycles up to 300: (a) S60-NCNS, (b) S65-NCNS and (c) S70-NCNS.

Table S1. Calculated volume occupied by sulfur (^{V_S}) and Li_2S ($^{V_{Li_2S}}$) *vs* the pore volume

S-NCNS	M_{NCNS}[1]	V_P[2]	M_S[3]	V_S[4]	V_{Li_2S}[5]
Composite	$g\ g_{S-NCNS}^{-1}$	$cm^3 g_{S-NCNS}^{-1}$	$g\ g_{S-NCNS}^{-1}$	$cm^3 g_{S-NCNS}^{-1}$	$cm^3 g_{S-NCNS}^{-1}$
S60-NCNS	0.40	0.68	0.60	0.29	0.52
S65-NCNS	0.35	0.60	0.65	0.31	0.56
S70-NCNS	0.30	0.51	0.70	0.34	0.61

provided by the NCNS host in the S-NCNS composites (^{V_P}).

[1] Fraction of NCNSs in the S-NCNS composite by weight;
[2] Calculated from $^{M_{NCNS}}$ and the total pore volume of NCNSs (1.7 cc g^{-1}), see main text.
[3] Fraction of sulfur in the S-NCNS composite by weight;
[4] Calculated from ^{M_S} and sulfur density of 2.06 g cm^{-3}.
[5] Calculated from Li_2S density of 1.66 g cm^{-3}.

Table S2. Comparison between the 5 mg cm^{-2} cathodes of this study and recently reported high sulfur-loading cathodes.

Reference Number*	d_{cat} μm	A_S mg cm^{-2}	C_S mAh g^{-1}	f_S %	f_{elec} μL mg^{-1}	$G_{C+0.5E}$ mAh g^{-1}	V_C mAh cm^{-3}
14	105	5.2	712.0	66.0	5.0	283.1	352.6
30	160	10.8	900.0	64.0	4.9	224.1	607.5
31	300	30.7	825.0	94.0	6.8	184.7	844.3
32	240	10.0	830.0	58.0	10.0	123.4	345.8
32	350	20.0	800.0	66.0	10.0	122.8	457.1
32	160	6.0	1200.0	52.0	10.0	173.3	450.0
33	1400	9.8	800.0	83.0	29.0	51.0	56.0
34	600	18.1	800.0	55.0	14.1	90.0	241.3
39	140	4.8	830.0	55.0	14.4	92.2	284.6
39	210	7.2	790.0	55.0	11.3	106.1	270.9
50	110	5.0	1300.0	58.0	10.6	185.1	590.9
51	150	5.0	760.0	38.0	6.0	135.0	253.3
52	100	4.2	1200.0	66.0	10.0	184.2	504.0
53	750	17.3	800.0	54.0	7.0	149.6	184.5
54	360	11.4	900.0	56.0	10.5	127.7	285.0
S60-NCNS**	80	5	1120	42.9	6	210.3	700.9
S65-NCNS**	65	5	1010	48.2	6	198.9	776.5
S70-NCNS**	55	5	900	53.9	6	186.1	821.6

* Reference numbers and symbols are defined in the main text.

** This study.