Electronic Supplementary Information

Strong contribution of pore morphology to high-rate electrochemical performance of lithium-ion battery

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Experimental

Synthesis of ordered mesoporous carbon with interconnected pore (OMC-IP). OMC-IP was fabricated by using a hard-templating procedure, in which phenol/formaldehyde (PF) resin and ordered mesoporous silica SBA-15 were used as the carbon source and hard template, respectively. The SBA-15 was prepared according to the method described in the reference.¹ For the synthesis of the PF resin,² 0.61 g of phenol was melted in a flask and mixed with 0.13 mL of 5 mol/L NaOH aqueous solution under stirring. 1.05 g of 37 wt% formaldehyde solution was then added. Subsequently, the clear mixture was reacted at 70 °C for 1 h under stirring and

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then was cooled to room temperature. The pH was adjusted to ~7.0 by 5 mol/L HCl aqueous solution. The product was dissolved in ethanol to obtain a 10 mL of water-soluble PF resin solution. After that, 1 g of SBA-15 powder was added to the obtained water-soluble PF resin solution and stirred until dry completely at room temperature, followed by heating for 24 h at 100 °C. The PF resin/silica nanocomposite was carbonized for 3 h at 900 °C in N₂ flow. The heating rate was 1 °C/min below 600 °C and then was increased to 5 °C/min above 600 °C. After that, the resulting carbon/silica nanocomposite was treated using 40 wt% HF to remove silica, washed, filtrated and then dried, leading to the formation of OMC-IP.

Synthesis of ordered mesoporous carbon with channel-like pore (OMC-CP). OMC-

CP was fabricated by a soft-templating procedure, in which PF resin and triblock copolymers Pluronic F127 (EO_{106} -PO₇₀- EO_{106}) were used as the carbon source and soft template, respectively.² In a typical synthesis, 1 g of F127 was dissolved in ethanol/H₂O (25 mL/2 mL) mixture solvent under stirring, followed by being mixed with 10 ml water-soluble PF resin ethanol solution (see *Synthesis of* OMC-IP). The obtained homogeneous mixture was transferred to a dish and then evaporated for about 24 h at room temperature, followed by heating for 24 h at 100 °C. The asprepared product was carbonized for 3 h at 900 °C in N₂ flow, leading to the formation of OMC-CP. The heating rate was 1 °C/min below 600 °C and then was increased to 5 °C/min above 600 °C.

Structural characterization. The microstructure of the samples was investigated by a FEI Tecnai G2 Spirit transmission electron microscope (TEM). XRD patterns were

recorded on a D-MAX 2200 VPC diffractometer using Cu K α radiation (40 kV, 30 mA). The unit cell parameter (*a*) was calculated using the formula $a = 2d_{10}/\sqrt{3}$, where d_{10} represents the d-spacing value of the 10 diffraction. N₂ adsorption measurements were carried out using a Micromeritics ASAP 2010 analyzer at 77 K. The BET surface area (S_{BET}) was analyzed by Brunauer-Emmett-Teller (BET) theory. The pore size distribution was derived from the adsorption branch by Barrett-Joyner-Halendar theory combined with Kruk-Jaroniec-Sayari correction. The thickness of carbon wall (T_{CW}) was calculated according to the equation T_{CW} = $a - D_C$, where D_C stands for the diameter of mesopores which is obtained from BJH pore size distribution. Raman measurements were carried out with inVia-Reflex Renishaw Raman system. Elemental analysis was performed on an Elementar Analysensysteme GmbH Vario EL analyzer. XPS measurements were carried out with an ESCALAB250 instrument. FTIR measurements were performed with IR spectroscopy (Bruker TENSOR 27), using KBr disk method.

Electrochemical characterization. The electrochemical performance of the samples was measured in 2032 coin cells. Li metal was used as counter/reference electrode. The working electrode was made of active materials (80 wt%), super P (10 wt%) and polyvinylidene fluoride (PVDF) (10 wt%) slurry coated onto a copper foil substrate. The electrodes were cut into circular disks with a diameter of 12 mm and a mass loading of about 0.4 ± 0.1 mg in each electrode. The electrolyte was 1 mol/L LiPF₆ in a mixture of ethylene carbonate (EC), dimethyl carbonate (DMC) and Diethyl carbonate (DEC) (1:1:1 by volume). A microporous membrane (Celgard 2300) was

used as the separator. The coin cells were assembled in an argon filled glove box (Mbraun). The galvanostatic charge/discharge tests were conducted in the potential range from 0.01 to 3.0 V at different current densities.

Sample	а	$\mathbf{S}_{\mathrm{BET}}$	D _c	T _{CW}
	(nm)	(m ² /g)	(nm)	(nm)
OMC-CP	11.1	896	4.6	6.5
OMC-IP	11.1	1030	4.3	6.8

Table S1 Nanostructure parameters of OMC-CP and OMC-IP

Table S2 Parameters of wide-angle XRD patterns of OMC-CP and OMC-IP

Sampla	$2\theta_{002}$	2009	ainA	β_{002}	d_{002}	L_c
Sample	(°)	C080 ₀₀₂	SIII0 ₀₀₂	(°)	(nm)	(nm)
OMC-CP	24.2	0.978	0.209	4.8	0.369	1.67
OMC-IP	24.0	0.978	0.208	5.0	0.371	1.61

 Table S3 Parameters of Raman spectras of OMC-CP and OMC-IP

Sample –	Peak a	Peak area		Peak center (cm ⁻¹)	
	D	G	(nm)	D	G
OMC CR	2816488	115585	1.78	1347	1592
UNIC-CP		3			
OMC-IP	2334258	938547	1.75	1340	1587

Samula	XPS		Elemental analysis		
Sample	C (at%)	O (at%)	C (wt%) H (wt%)		
OMC-CP	88.2	11.8	81.1 2.3		
OMC-IP	89.8	10.2	80.1 2.5		

 Table S4 Elemental composition information of OMC-CP and OMC-IP



Fig. S1. Schematic illustration of preparation of (a) OMC-IP by hard-templating procedure and (b) OMC-CP by soft-templating procedure.



Fig. S2. SEM images of (a) OMC-CP and (b) OMC-IP.



Fig. S3. N₂ adsorption-desorption isotherms of OMC-CP and OMC-IP.



Fig. S4. Wide-angle XRD patterns of OMC-IP and OMC-CP.



Fig. S5. Raman spectrums of (a) OMC-IP and (b) OMC-CP.



Fig. S6. FTIR spectrums of OMC-IP and OMC-CP.



Fig. S7. XPS spectrums of OMC-IP and OMC-CP.



Fig. S8. Charge-discharge profiles of (a) OMC-IP and (b) OMC-CP in the first three cycle measured at 100 mA/g. The first discharge capacity of OMC-CP (*i.e.*, 4101 mAh/g) is very close to that of OMC-IP (*i.e.*, 3934 mAh/g), which considerably exceed the theoretical capacity of graphite (*i.e.*, 372 mAh/g).³ It is suggested that in addition to the classical graphite intercalation mechanism, there exist other lithium storage mechanisms. For example, large numbers of nanopores could act as cavities for lithium storage in form of lithium clusters, which can be reflected by the slope at ca. 1.4 V in the charge-discharge curves.⁴ Furthermore, the slope from 2.5 to 3.0 V should be ascribed to the bonding between lithium and hydrogen atoms at the edge of carbon sheets.⁵ The existence of these multiple lithium-storage positions in OMC-CP and OMC-IP gives rise to high capacities.



Fig. S9. Cyclability of OMC-CP and OMC-IP at (a) 100 mA/g and (b) 1000 mA/g.



Fig. S10. The modified equivalent circuit of the impedance.

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