Supporting Information:

Ionic liquid induced tunable N-doped mesoporous carbon spheres for supercapacitor

Haixia Wu,[a,b] Haijun Lv,[b] Yue Zhang, [b] Juan Du, [b,]* Aibing Chen [b,]*

[a]School of Chemical Engineering and Technology, Tianjin University, Tianjin 300072, P.R. China.

[b]College of Chemical and Pharmaceutical Engineering, Hebei University of Science and Technology, 70 Yuhua Road, Shijiazhuang 050018, China.

*Corresponding Author: E-mail: chen_ab@163.com; dujuan_chemistry@163.com

Experimental Section

Synthesis of N-MCS samples

EtOH was added in H_2O and 1-tetradecyl-3-methylimidazolium bromide ($[C_{14}Mim]Br$) surfactant solution (110 mM, dissolved in a 2:1 mixture of H_2O and EtOH) was quickly added under vigorous stirring and then add the resorcinol stirring for 30 min. TEOS was added to the reaction mixture and subsequently stirred at ambient temperature overnight. The as-synthesized suspension was centrifuged and dried at 70 ^oC overnight. For carbonization, the obtained product was heated at 800 ^oC for 3 h with a heating rate of 3 ^oC min^{-1} under N_2 atmosphere. Finally, the MCS were obtained, after removing the silica with 10 wt% HF solution for 24 h. The detail amount of reagents for preparation of N-MCS samples with different structure and morphology was shown in Table S1.

In addition, to investigate the effect of N-doping for N-MCS samples, the yolk-shell MCS was also prepared by the same method using Cetyltrimethylammonium bromide (CTAB) as template instead of [C_{14}Mim]Br.

Table S1 Detail amount of reagents for preparation of N-MCS samples with different concentration and amount of RF.

Samples	H_2O (mL)	EtOH (mL)	NH_4OH (g mL^{-1})	[C_{14}Mim]Br (g)	Resorcinol (g)	TEOS (g)
N-MCS-S0.5	440	220	0.004	1.2	0.43	2.15
N-MCS-1	220	110	0.004	1.2	0.43	2.15
N-MCS-S3	73	37	0.004	1.2	0.43	2.15
N-MCS-S5	44	22	0.004	1.2	0.43	2.15
N-MCS-R0.5	220	110	0.004	1.2	0.215	2.15
N-MCS-R2	220	110	0.004	1.2	0.86	2.15
N-MCS-R3	220	110	0.004	1.2	1.29	2.15

Characterizations

The morphology and microstructure of samples were investigated by transmission electron microscopy (TEM, JEOL JEM-2100). Nitrogen adsorption-desorption isotherms were carried out on a Micromeritics TriStar 3020 instrument at -196 °C. The Brunauer-Emmett-Teller (BET) method was employed to calculate the specific surface area, while the Barrett-Joyner-Halenda (BJH) method was applied to analyze the pore size distribution using the desorption branch of isotherm. The total pore volume was obtained from the amount of N_2 adsorbed at the relative pressure ($P/P_0 = 0.97$). The composition of C, H and N content of N-MCS-R0.5 and MCS was evaluated using elemental analysis (CHN) on the Flash EA 1112.

Electrochemical Measurements

The working electrode was prepared by coating the viscous slurry (samples, carbon black and polytetrafluoroethylene with the mass ratio of 8:1:1 in ethanol) onto Ni foam current collector. The mass of active material loaded on each working electrode was 4~5 mg after drying at 100 °C for 24 h. Electrochemical measurements were carried out in both three-electrode and two-electrode system using an electrochemical workstation (CHI 760E, Chenhua Instruments, China) with 6 M KOH solution as the electrolyte. For three-electrode system, a Pt wire and Hg/HgO was used as the counter and reference electrodes. For the fabrication of supercapacitor devices, two slices of electrode were immersed in 6 M KOH and were separated by a filtration paper, then tested by the current collector. Electrochemical performances were evaluated by cyclic voltammetry (CV), galvanostatic charge-discharge (GCD) and electrical impedance spectroscopy (EIS) analysis. For the two-electrode system, the specific capacitances (C, F g^{-1}), energy density (E, Wh kg^{-1}) and power density (P, W kg^{-1}) were calculated by the following equations: $C=4I\Delta t/\Delta Vm$, $E=0.5C(\Delta V)^2/4$ and $P=E/\Delta t$, where I (A), Δt (s), ΔV (V) and m (g) are GCD current, discharge time, voltage window, and mass of active material, respectively. In three-electrode system, the specific gravimetric capacitance according to the GCD measurements: $C=I\Delta t/\Delta Vm$.

Table S2 Detail information for the structure of N-MCS samples with different concentration and amount of RF.

Samples	Structure	Diameter(nm)
N-MCS-S0.5	Core-shell	420
N-MCS-1	Core-shell	400
N-MCS-S3	plicated	300
N-MCS-S5	Hollow	160
N-MCS-R0.5	Core-shell	340
N-MCS-R2	Lemon-like	420
N-MCS-R3	Solid	1000

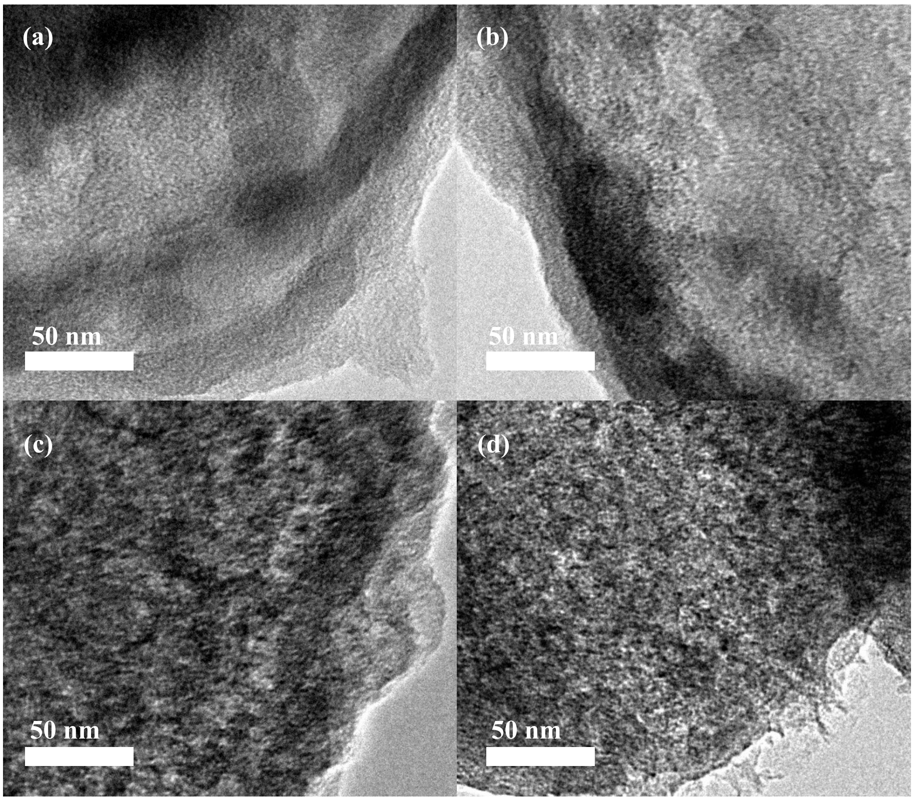

Fig. S1. TEM images with high resolution of N-MCS samples with different solvent volume of reaction system (N-MCS-S0.5 (a), N-MCS-1 (b) N-MCS-S3 (c), N-MCS-S5 (d)).

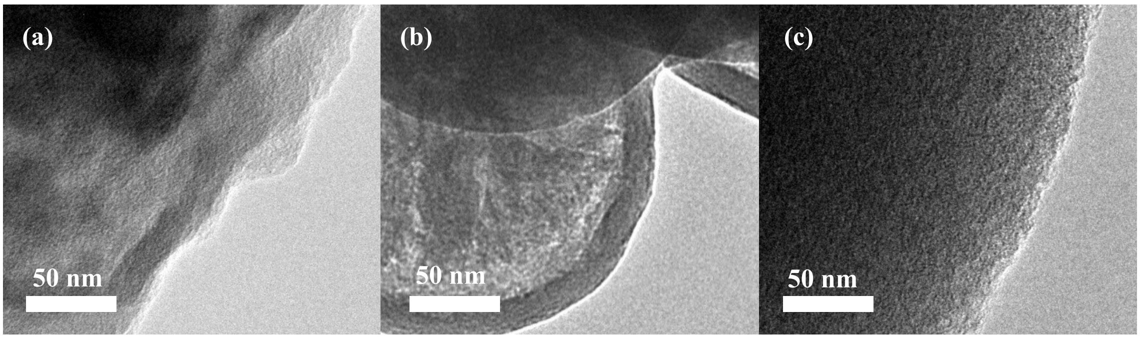

Fig. S2. TEM images with high resolution of N-MCS with different amounts of resin (N-MCS-R0.5 (a), N-MCS-R2 (b) and N-MCS-R3 (c)).

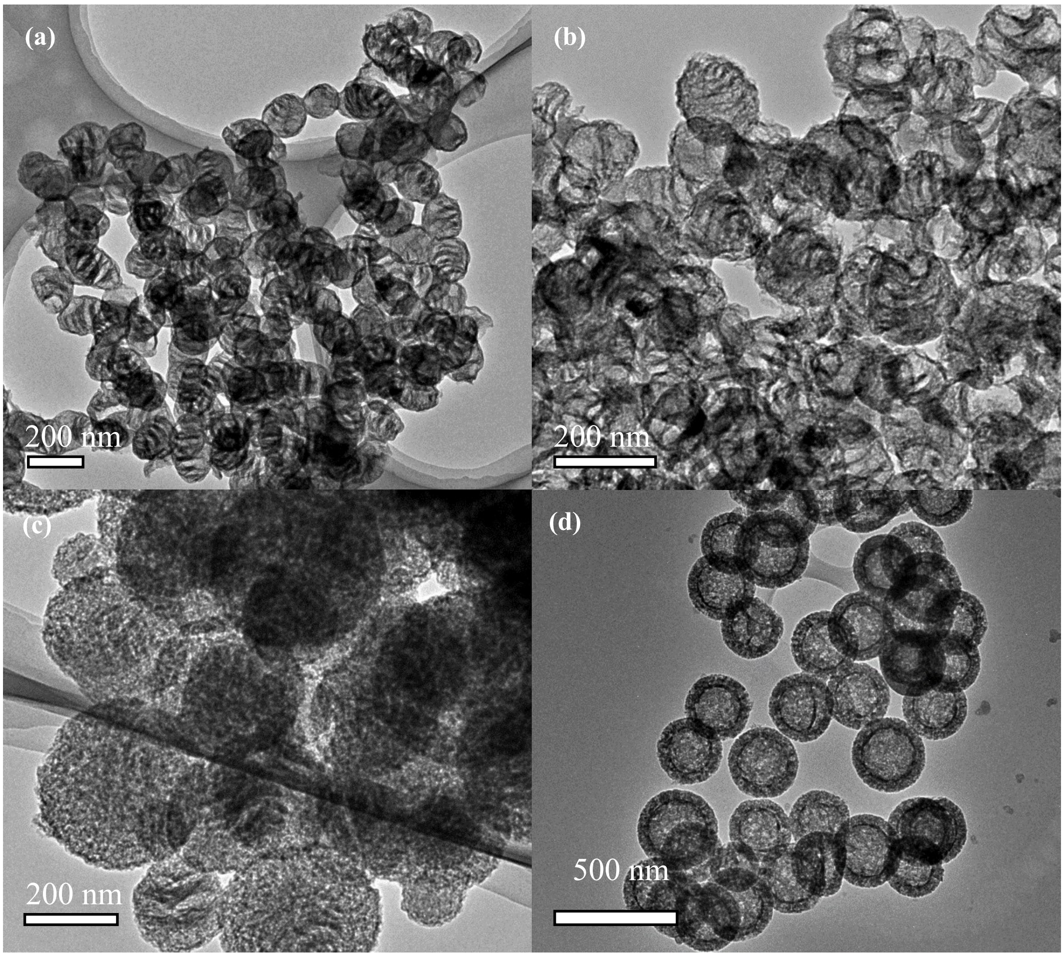

Fig. S3. TEM images of N-MCS-C16-0.5 (a), N-MCS-C16-1 (b), N-MCS-C16-3 (c) and N-MCS-C16-5 (d) prepared by [C_{16}Mim]Br as template with different concentration of reaction system.

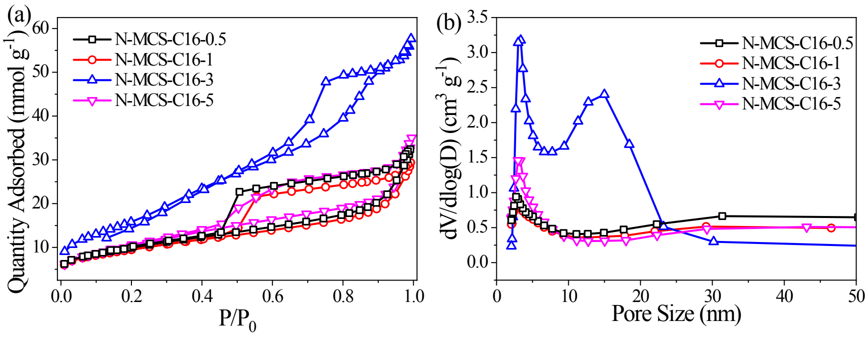

Fig. S4. N_2 adsorption-desorption isotherm (a) and pore size distribution (b) of N-MCS prepared by $[C_{16}Mim]Br$ as template with different concentration of reaction system (solvent).

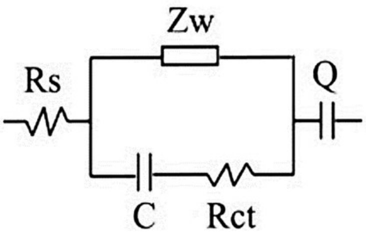

Fig. S5. The fitted equivalent circuits of the EIS.

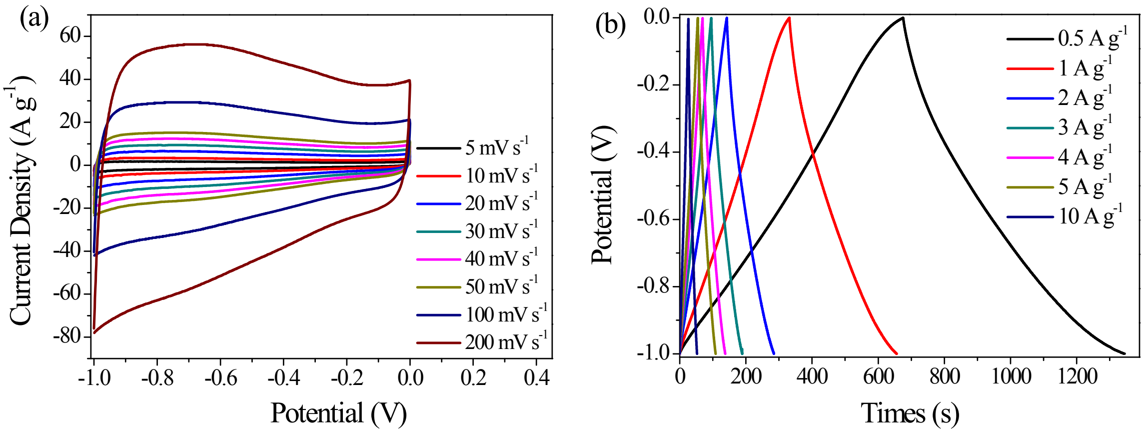

Fig. S6. CV curves at different scan rates (a), GCD curves at different current densities (b) of N-MCS-R0.5 in two-electrode system.

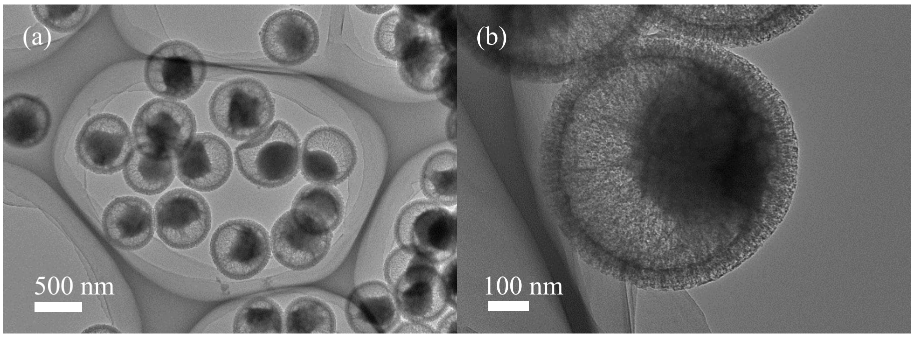

Fig. S7. TEM images of yolk-shell MCS without N-doping prepare by CTAB as template.

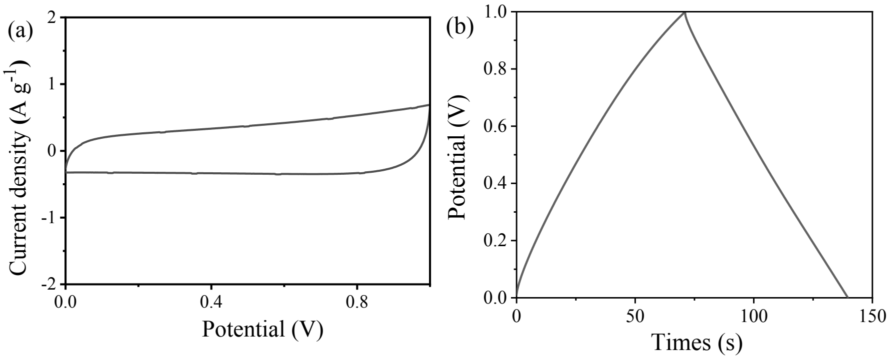

Fig. S8. CV curves at scan rate of 5 mV s^{-1} (a) and GCD curves at current density of 0.5 A g^{-1} (b) of yolk-shell MCS without N-doping prepare by CTAB as template in two-electrode system.

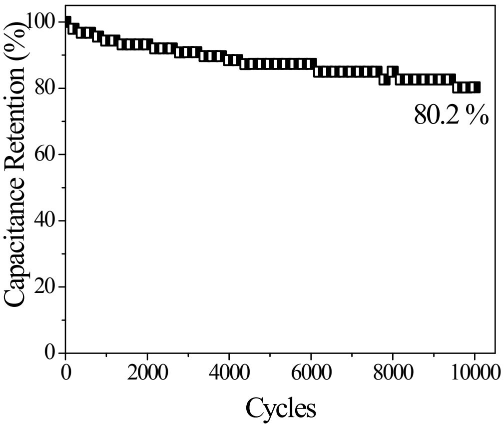

Fig. S9. Cycle ability of N-MCS-R0.5 at current density of 2 A g^{-1} in two-electrode system.