Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supporting Information

Design of Unique Porous Carbons with Double Support Structure: Toward Overall Performance by Employing Bidirectional Anchoring Strategy

*Yujing Liu, Chengyao Zhao, Qi Liu, Xin Zhou, Zhongqiu Liu, Jinmao You, Anguo Ying**

School of Chemistry and Chemical Engineering, Qufu Normal University, Qufu 273100, China

E-mail: yinganguo@163.com

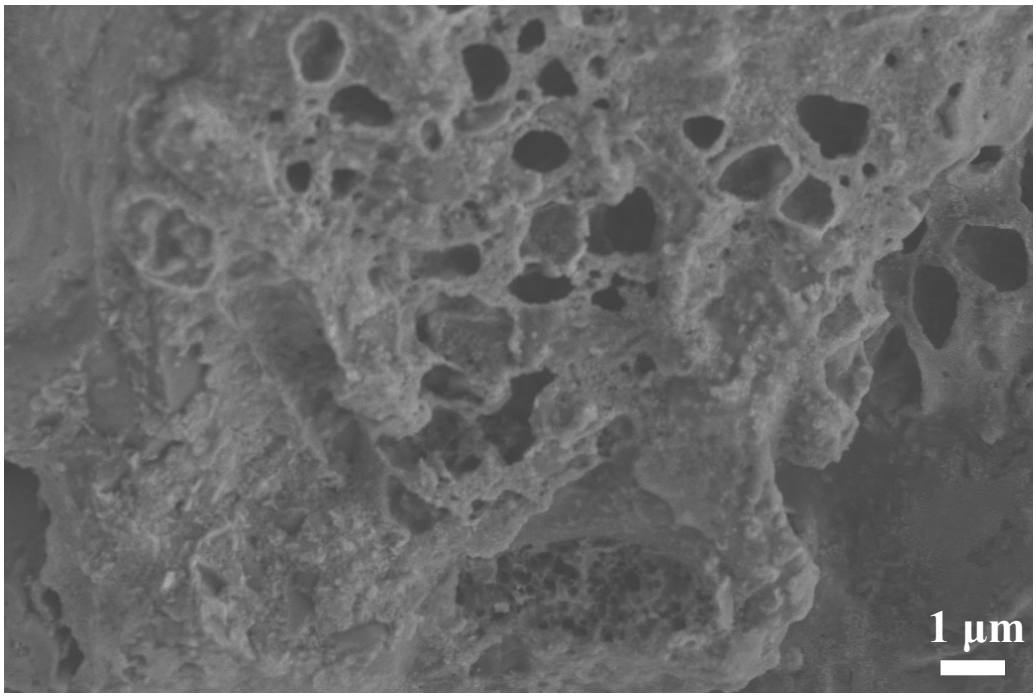

Figure S1 SEM image of C4VP.

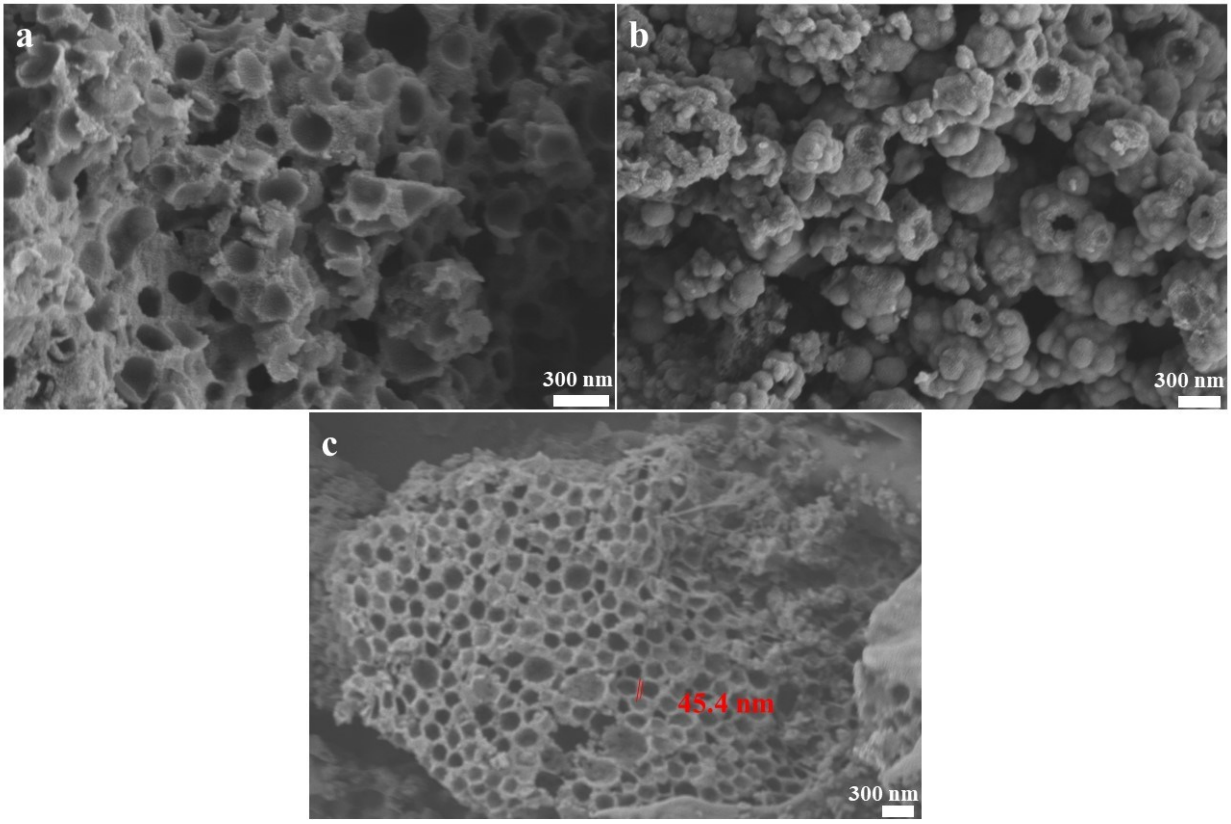

Figure S2 SEM images of P(St-co-4VP)@PAN-based carbons obtained via the template method. (a,c) honeycomb structure. (b) hollow structure.

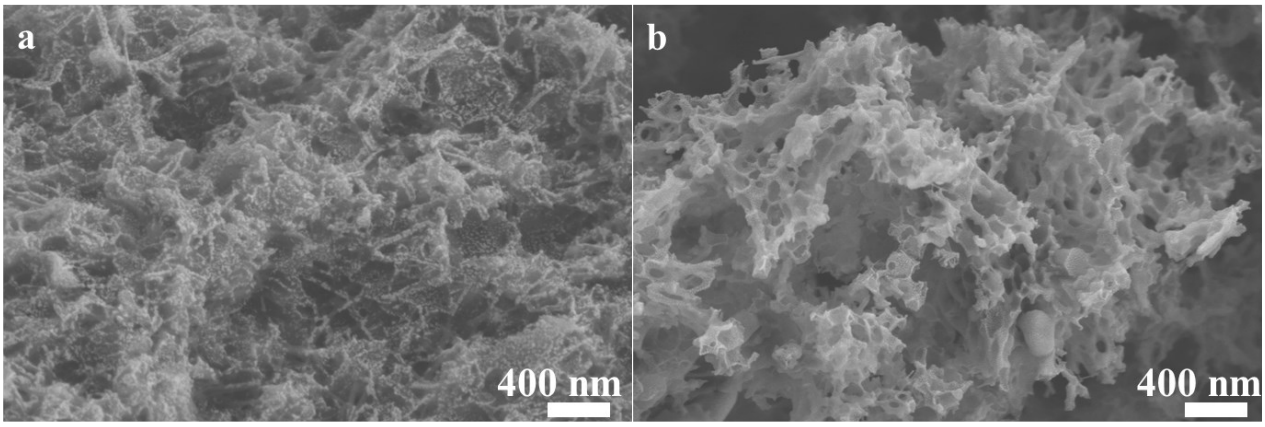

Figure S3 SEM images of P(St-co-4VP)@PAN-derived carbon materials with different PAN loading via the bidirectional anchoring method. (a) 0.04 g. (b) 0.08 g.

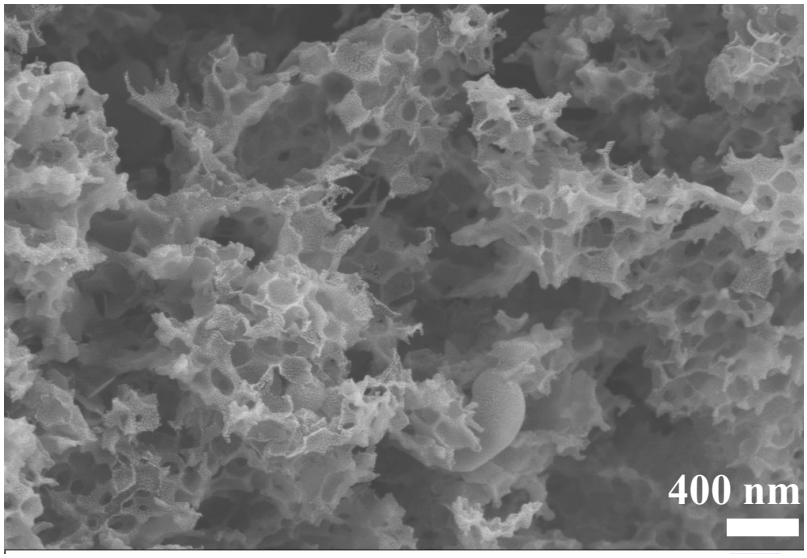

Figure S4 SEM image of CPCS treated at 950 °C.

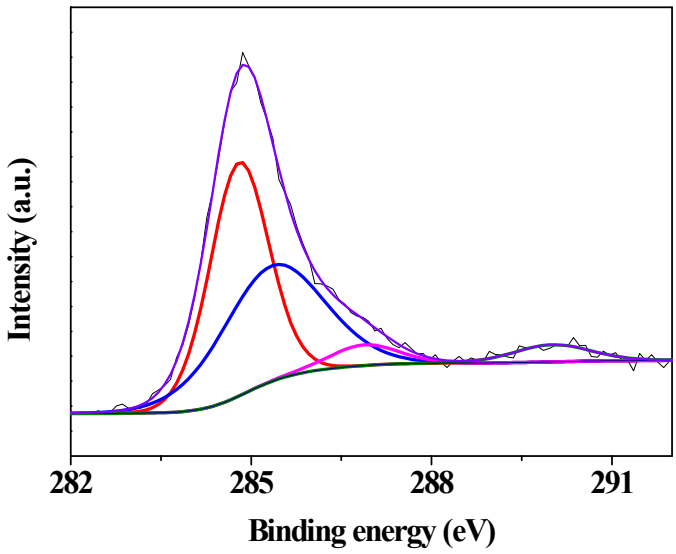

Figure S5 XPS C 1s spectra.

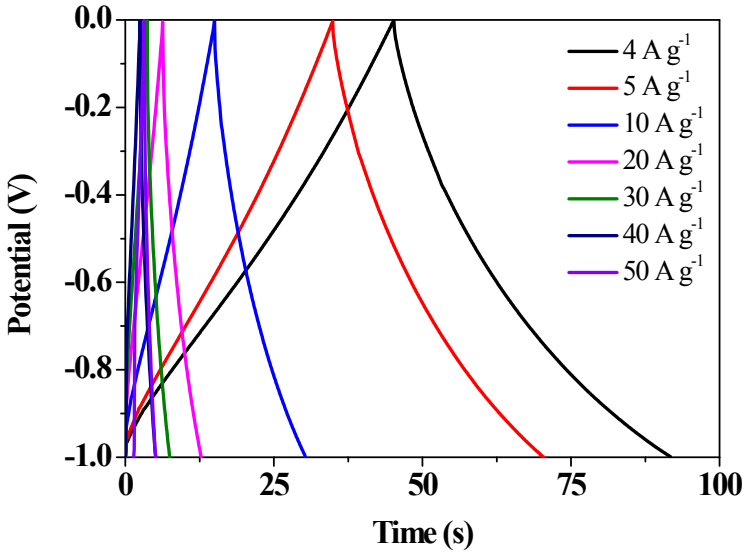

Figure S6 GCD curves of CPCS with current densities ranging from 4 to 50 A g^{-1}.

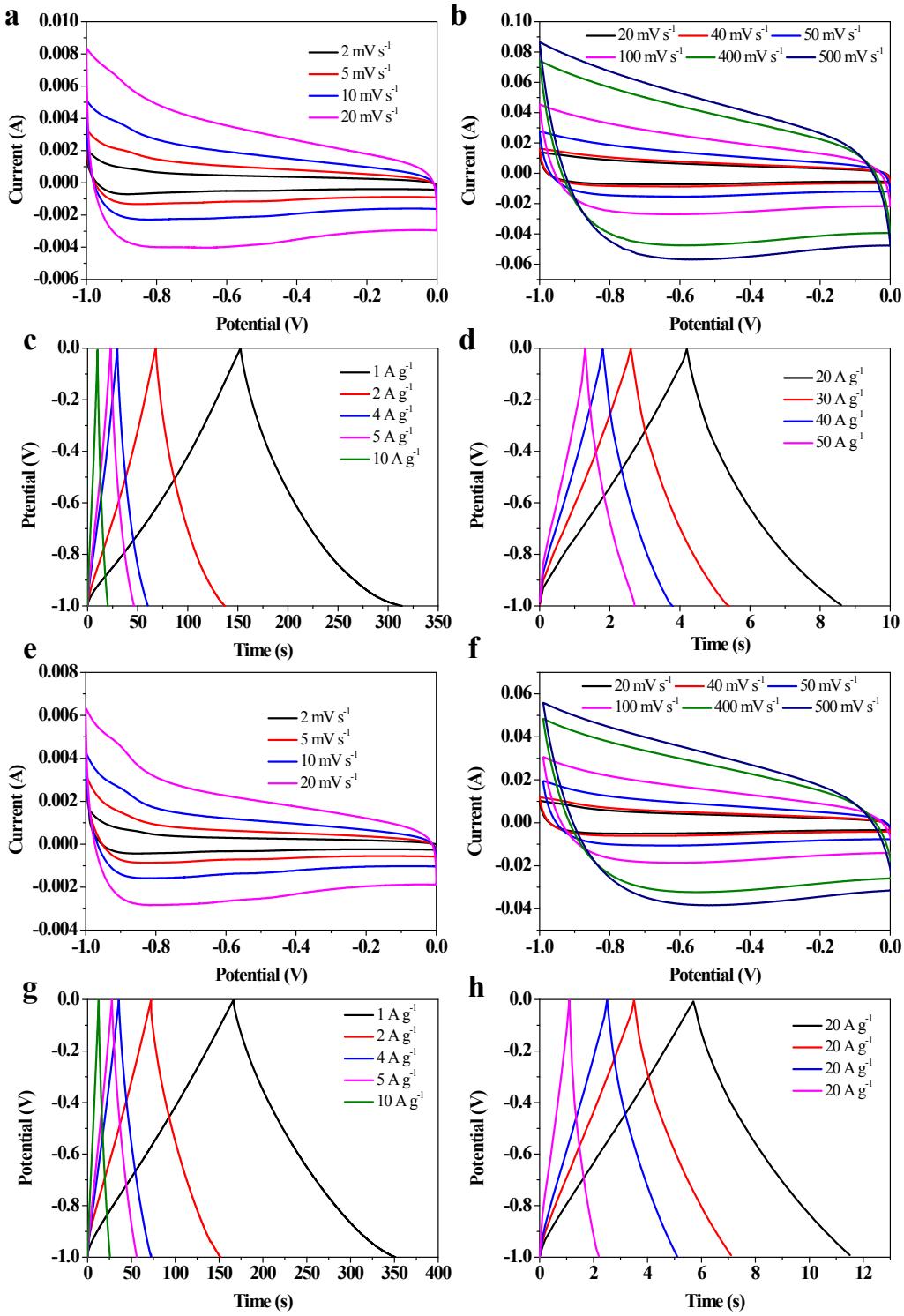

Figure S7 (a-b) CV curves of HCM at different scan rates. (c-d) GCD curves of HCM at different current densities. (e-f) CV curves of HPC at different scan rates. (g-h) GCD curves of HPC at different current densities.

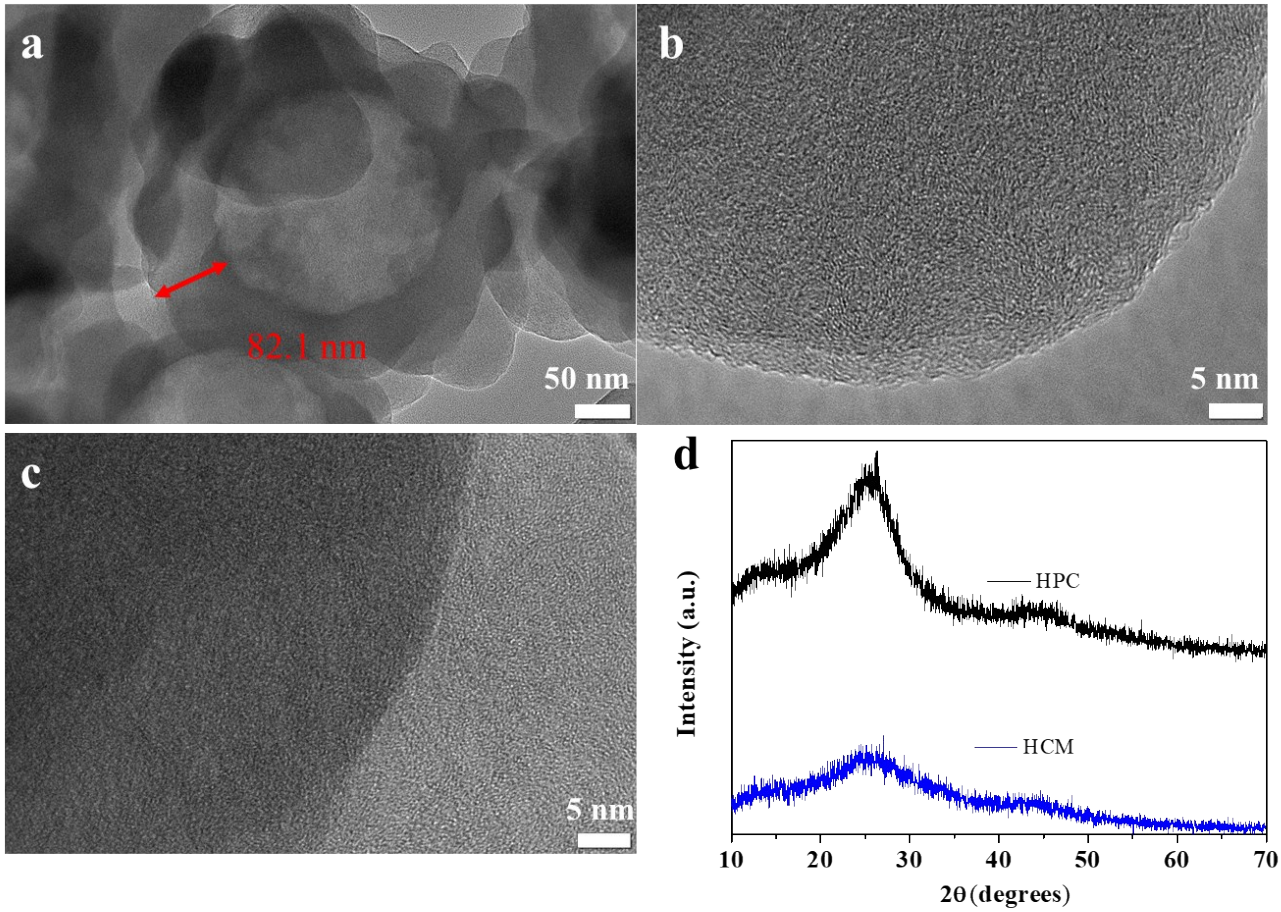

Figure S8 (a) TEM image of HPC with hollow structure. (b) HRTEM image of HPC. (c) HRTEM image of HCM. (d) Wide-angle PXRD patterns of HCM and HPC.

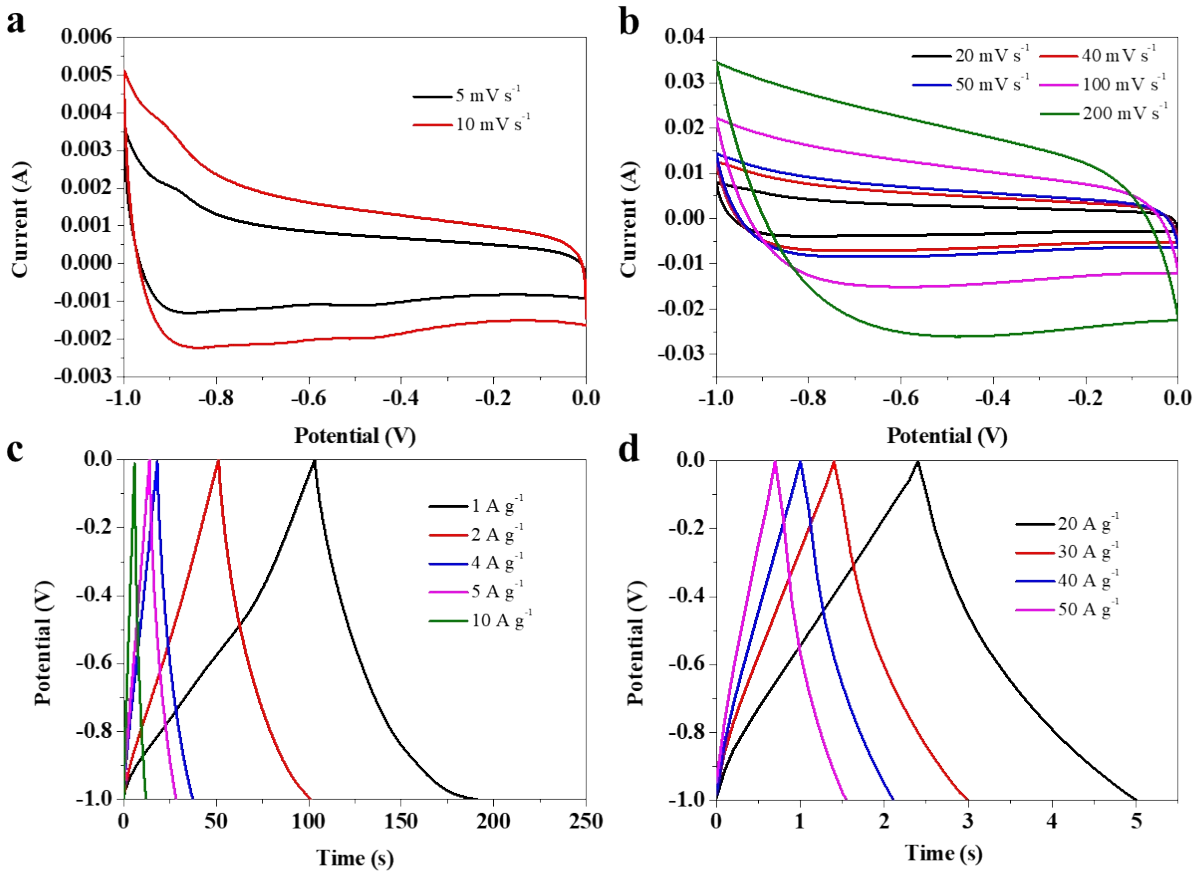

Figure S9 (a-b) CV curves of C4VP at different scan rates. (c-d) GCD curves of C4VP at different current densities.

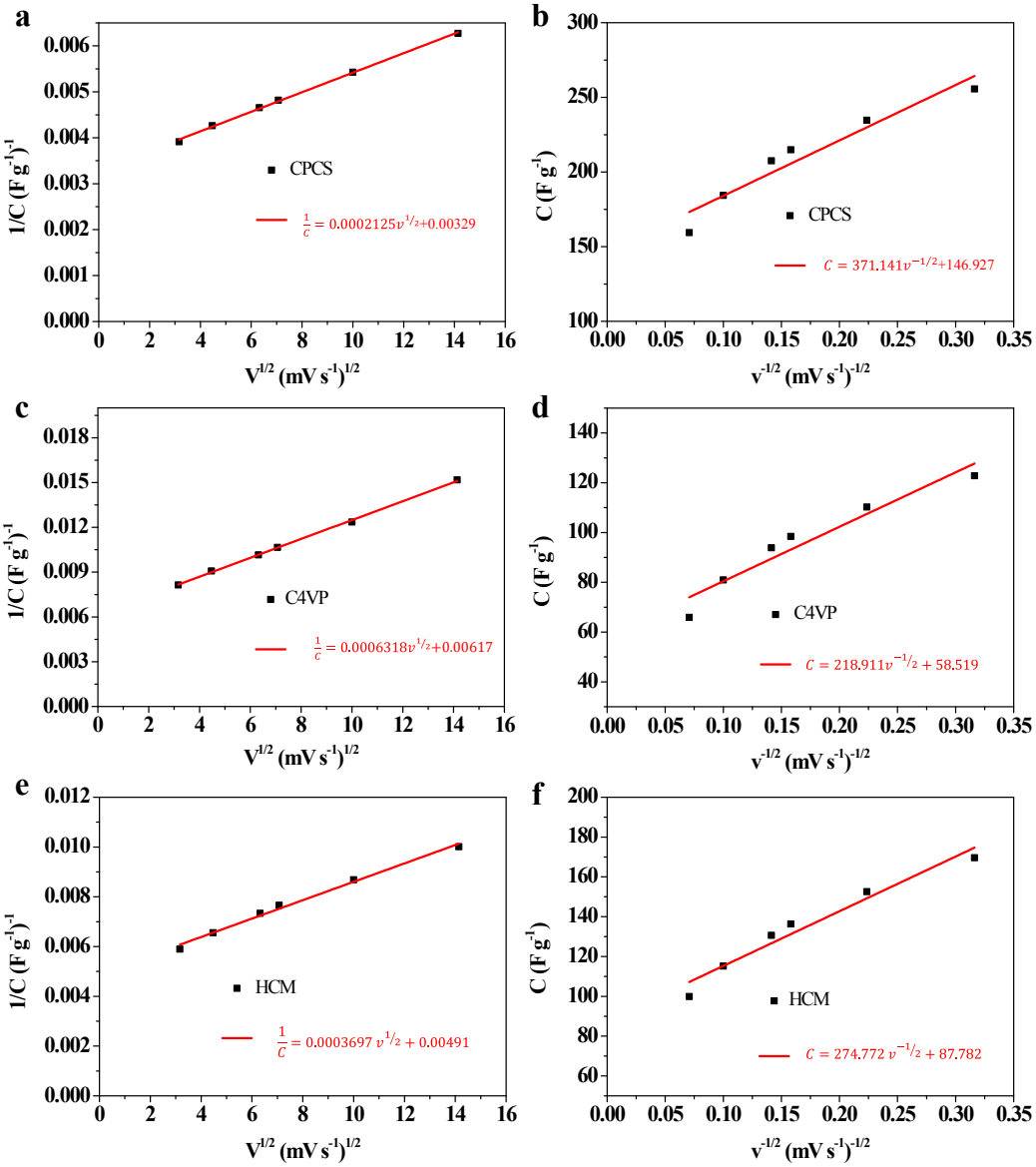

Figure S10 (a, c, e) Plots of reciprocal of calculated gravimetric capacity (C^{-1}) vs. square root of scan rate ($v^{1/2}$) of the CPCS, C4VP and HCM, separately. (b, d, f) Plots of calculated gravimetric capacity (C) vs. reciprocal of square root of scan rate ($v^{-1/2}$) of the CPCS, C4VP and HCM, separately. (Insert: the algebraic equations of the fitting lines)

Table S1 Summary of the specific surface areas and packing densities of the CPCS, HPC and HCM.

Samples	SSA ($m^2 g^{-1}$)	V ($cm^3 g^{-1}$)	Packing density ($g cm^{-3}$)
CPCS	26.95	0.556	0.75
HPC	23.22	0.228	0.78
HCM	18.36	0.178	0.79

Table S2 The electrochemical performance of doped carbons without activation treatment.

Materials	SSA ($m^2 g^{-1}$)	C_G ($F g^{-1}$)	C_V ($F cm^{-3}$)	C_A ($\mu F cm^{-2}$)	Ref.
r-GO[a]	264.4	225	-	1.19	1
N, P, Si-CNF[b]	10.94	243.7	253.4	-	2
SiPDC[c]	641.51	276	-	0.43	3
3D-B, N-CNF[d]	351.5	295	-	158.2	4
NS-GNP[e]	245	289	214	-	5
NPSiDC[f]	228.4	318	0.67	-	6
PNDC[g]	362.8	270	0.42	-	7
CPCS[h]	26.95	308.89	231.67	1146	This work

a. Reduced graphene oxide; b. N, P, Si- tri-doped carbons; c. Si, N-doped carbon; d. N, B-co-doped 3D hierarchical porous carbon network; e. N, S-co-doped graphene nanobots; f. N, P, Si-tri-doped C; g. P, N co-doped C. h. Coralloid-like porous carbon sheets.

Supplementary References

[1] S. H. Tamboli, B. S. Kim, G. Choi, H. Lee, D. Lee, U. M. Patil, J. Lim, S. B. Kulkarni, S. Chan Jun, H. H. Cho, Post-heating effects on the physical and electrochemical capacitive properties of reduced graphene oxide paper, *J. Mater. Chem. A*, **2014**, *2*, 5077.

[2] Y. Yang, X. Hou, C. Ding, J.-L. Lan, Y. Yu, X. Yang, Eco-friendly fabricated nonporous carbon nanofibers with high volumetric capacitance: improving rate performance by tri-dopants of nitrogen, phosphorus, and silicon, *Inorg. Chem. Front.,* **2017**, 4, 2024.

[3] S. K. Ramasahayam, U. B. Nasini, A. U. Shaikh, T. Viswanathan, Novel Tannin-Based Si, P Co-Doped Carbon for Supercapacitor, Applications, *J. Power Sources*, **2015**, 275, 835.

[4] B. Dahal, T. Mukhiya, G. P. Ojha, A. Muthurasu, S.-H. Chae, T. Kim, D. Kang, H. Y. Kim,

In-built fabrication of MOF assimilated B/N co-doped 3D porous carbon nanofiber network as a binder-free electrode for supercapacitors, *Electrochim. Acta,* **2019**, 301, 209.

[5] K. Gopalsamy, J. Balamurugan, T. D. Thanh, N. H. Kim, J. H. Lee, Fabrication of nitrogen and sulfur co-doped graphene nanoribbons with porous architecture for high-performance supercapacitors, *Chem. Eng. J.*, **2017**, 312, 180.

[6] S. K. Ramasahayam, Z. Hicks, T. Viswanathan, Thiamine-Based Nitrogen, Phosphorus, and Silicon Tri-doped Carbon for Supercapacitor Applications, *ACS Sustainable Chem. Eng.,* **2015**, 3, 2194.

[7] S. K. Ramasahayam, A. L. Clark, Z. Hicks, T. Viswanathan, Spent coffee grounds derived P, N co-doped C as electrocatalyst for supercapacitor applications, *Electrochim. Acta,* **2015**, 168, 414.