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

Heterogeneous structured pomegranate-like Bi@C nanospheres for high-performance sodium storage

Jianhua Zhu, Jianwen Wang, Guanwu Li, Xiuli Zhu, Mengyang Cao, Yingpeng Wu*

State Key Laboratory of Chem/Bio-Sensing and Chemometrics, Provincial Hunan Key Laboratory for Graphene Materials and Devices, College of Chemistry and Chemical Engineering, Hunan University, Changsha, 410082, P. R. China.

E-mail: wuyingpeng@hnu.edu.cn

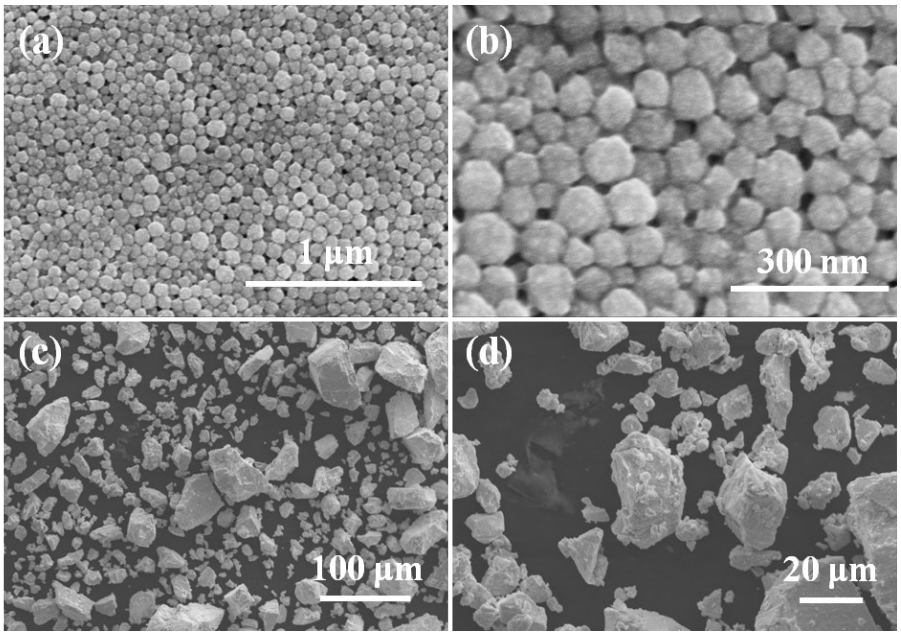

Fig. S1 (a), (b) SEM images of PBCNSs before carbonization. (c), (d) SEM of the commercial Bi powder.

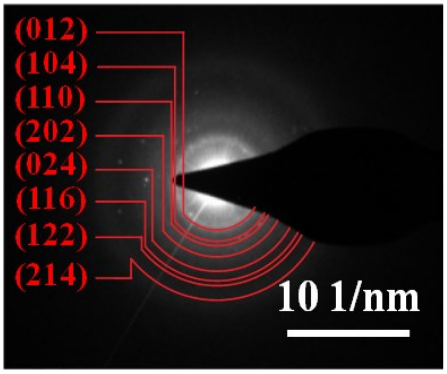

Fig. S2 Selected area diffraction of PBCNSs.

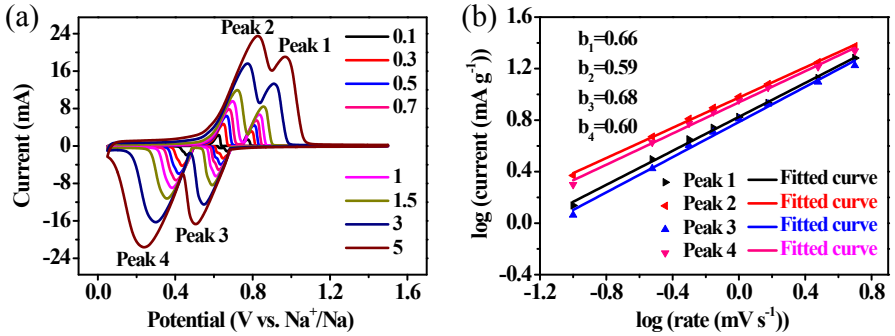

Fig. S3 (a) CV curves at different sweep rates (0.1-5 mV s^{-1}) of the PBCNSs anode for SIBs. (b) The corresponding log *I* vs. log *v* plots at each peak and the corresponding linear fits.

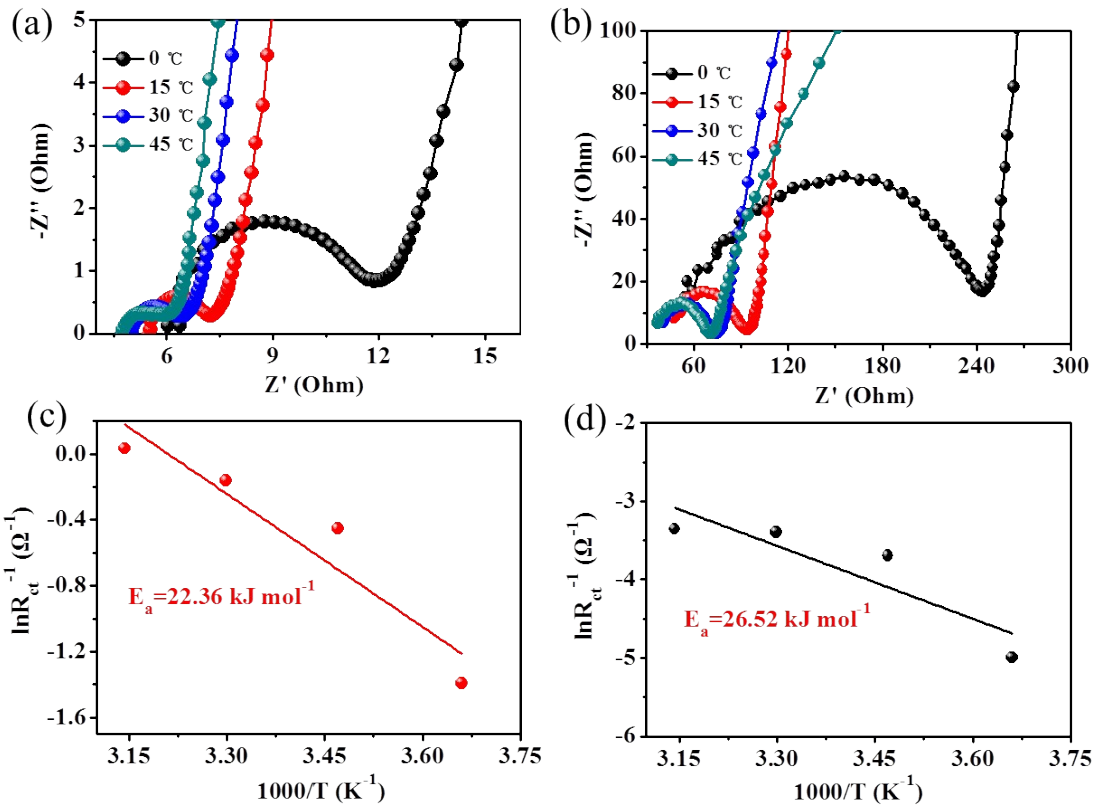

Fig. S4 Nyquist plots at different temperaures for (a) PBCNSs and (b) commercial Bi powder after 5 cycles. The activation energy for (c) PBCNSs and (d) commercial Bi powder.

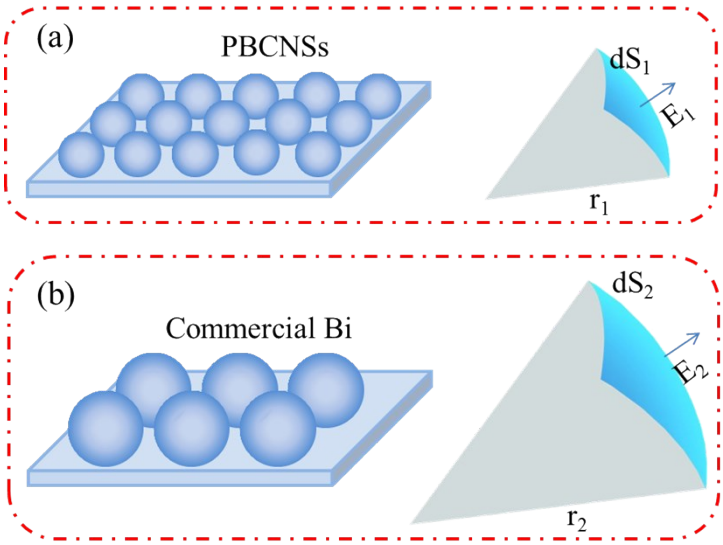

Fig. S5 Scheme of surface element in electrostatic field based on Gauss theorem for (a) PBCNSs and (b) commercial Bi powder.

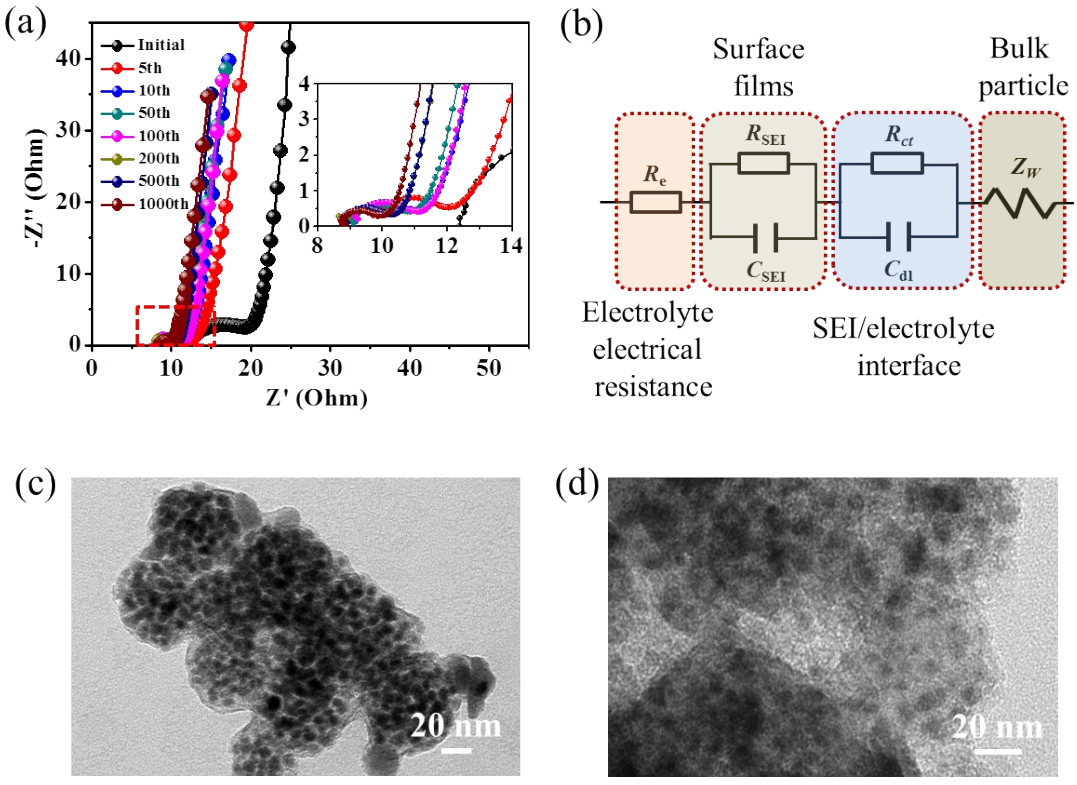

Fig. S6 (a) Nyquist plots of PBCNSs electrode at different cycles obtained by applying a sine wave with amplitude of 5.0 mV over the frequency range 0.1 Hz-100

kHz. (b) Randles equivalent circuit of the studied system. SEM images of PBCNSs electrodes before (c) and after 1000 cycles (d).

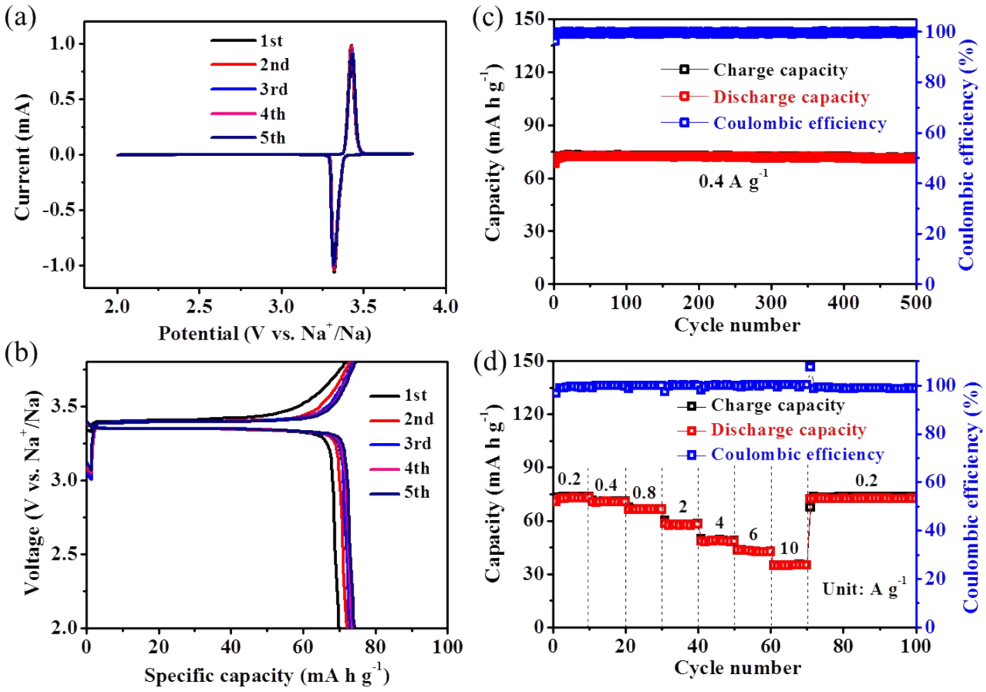

Fig. S7 Electrochemical performance of NVP@C: (a) CV curves at 0.1 mV s^{-1}, (b) galvanostatic charge/discharge curves at 0.4 A g^{-1}, (c) cycling performance with the corresponding Coulombic efficiency at 0.4 A g^{-1}, and (d) rate performance.

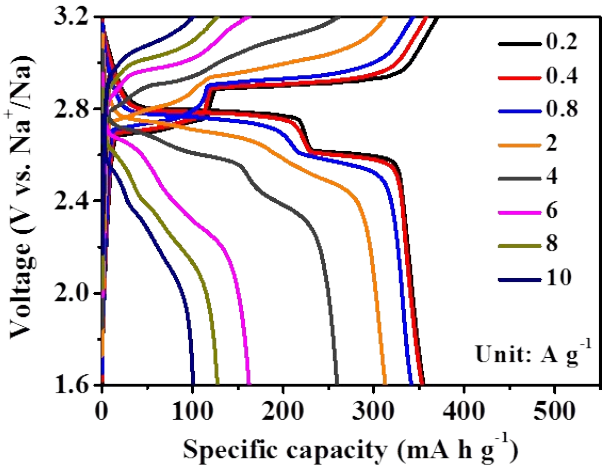

Fig. S8 Charge/discharge curves of the PBCNSs//NVP@C full cells at different current densities.

Table S1 Comparison of rate capability with reported Bi-based anode for SIBs.

Material/ Mass loading	Electrolyte/ Voltage	Carbon Content (wt%)	Cyclability (capacity retention (mA h g^{-1}) @cycle number)	Rate capability (capacity retention (mA h g^{-1}) @current density (A g^{-1}))	Ref.
PBCNSs 0.6-1.2 mg cm^{-2} PBCNSs 11.33 mg cm^{-2}	**1M $NaPF_6$/DME 0.05-1.5V**	**17.7**	**340@16000 at 20 A g^{-1} 327.2@315 at 0.5 A g^{-1}**	**372.8@25**	**This work**
Bi@C 0.8-1.0 mg cm^{-2} Bi@C 11.5 mg cm^{-2}	1M $NaPF_6$/DME 0.01-1.5V	26.7	265@30000 at 8 A g^{-1} 280@200 at 0.8 A g^{-1}	232@60	1
Bi@graphene 1.2 mg cm^{-2}	1M $NaClO_4$/EC:PC 0.01-1.5V	37.2	200@50 at 40 mA g^{-1}	250@1.28	2
Bulk Bi ~3 mg cm^{-2}	1M $NaPF_6$/DEGDME 0.01-2.0V	0	382@2000 at 0.4 A g^{-1}	355@2	3
Bi@graphite ~0.5 mg cm^{-2}	1M $NaPF_6$/DME 0.01-1.5V	70	~140@10000 at 3.2 A g^{-1}	113@48	4
Bi@N-C ~1 mg cm^{-2}	1M $NaPF_6$/DME 0.01-1.5V	38	235@2000 at 10 A g^{-1}	178@100	5
Bi@N-C ~1 mg cm^{-2}	1M $NaPF_6$/DME 0.1-2.1V	12.2	302@2000 at 10 A g^{-1}	368@2	6
Bi-C/CF 1-1.2 mg cm^{-2}	1M $NaClO_4$/PC With 5%FEC 0.01-1.5V	50.7	~340@500 at 0.5 A g^{-1}	110@2.4	7
Bi@Void@C 1-2 mg cm^{-2}	1M $NaPF_6$/DME 0.01-1.5V	38	198@10000 at 20 A g^{-1}	173@100	8

Table S2 The fitting resistance results for PBCNSs and commercial Bi power at different temperatures.

Material	Resistance (Ω)	0 ℃	15 ℃	30 ℃	45 ℃
PBCNSs	R_{ct}	4.025	1.485	1.572	0.966
Commercial Bi power	R_{ct}	147.4	40.26	29.77	28.61

Table S3 Comparison of EIS data for SIBs of the reported literature.

Anode material	Electrolyte	Cycle	R_{ct}(Ω)	Ref.
RGO@CoP@C-FeP	1M $NaClO_4$ in PC with 5 wt% FEC	10th	184.5	9
C/g-C_3N_4	0.8M $NaClO_4$ in EC/DEC	Initial	102.4	10
DMcT-MoO_3	1M $NaPF_6$ in DME	Initial	30.7	11
H-TiO_2@CFC	1M $NaClO_4$ in EMC/EC	Initial	110.5	12
TiO_2/MoS_2/RGO	1M $NaClO_4$ in EC/PC with 5 wt% FEC	Initial	133	13
CTNRs/rGO	1M $NaClO_4$ in EC/DMC	Initial	32.02	14
S-P/rGO	1M $NaClO_4$ in EC/DMC with 5 wt% FEC	Initial	132.8	15
PBCNSs	**1M $NaPF_6$ in DME**	10th 1000th	3.38 1.11	**This work**

References

1. P. Xiong, P. Bai, A. Li, B. Li, M. Cheng, Y. Chen, S. Huang, Q. Jiang, X. H. Bu and Y. Xu, *Adv. Mater.*, 2019, **31**, 1904771.

2. D. Su, S. Dou and G. Wang, *Nano Energy*, 2015, **12**, 88-95.

3. C. Wang, L. Wang, F. Li, F. Cheng and J. Chen, *Adv. Mater.*, 2017, **29**, 1702212.

4. J. Chen, X. Fan, X. Ji, T. Gao, S. Hou, X. Zhou, L. Wang, F. Wang, C. Yang and L. Chen, *Energy Environ. Sci.*, 2018, **11**, 1218-1225.

5. H. Yang, R. Xu, Y. Yao, S. Ye, X. Zhou and Y. Yu, *Adv. Funct. Mater.*, 2019, **29**, 1809195.

6. P. Xue, N. Wang, Z. Fang, Z. Lu, X. Xu, L. Wang, Y. Du, X. Ren, Z. Bai and S. Dou, *Nano Lett.*, 2019, **19**, 1998-2004.

7. Y. Zhang, Q. Su, W. Xu, G. Cao, Y. Wang, A. Pan and S. Liang, *Advanced Science*, 2019, **6**, 1970098.

8. H. Yang, L.-W. Chen, F. He, J. Zhang, Y. Feng, L. Zhao, B. Wang, L. He, Q. Zhang and Y. Yu, *Nano Lett.*, 2020, **20**, 758-767.

9. Z. Li, L. Zhang, X. Ge, C. Li, S. Dong, C. Wang and L. Yin, Nano Energy, 2017, **32**, 494-502.

10. G.-M. Weng, Y. Xie, H. Wang, C. Karpovich, J. Lipton, J. Zhu, J. Kong, L. D. Pfefferle and A. D. Taylor, Angew. Chem., 2019, **131**, 13865-13871.

11. B. Wang, E. H. Ang, Y. Yang, Y. Zhang, H. Geng, M. Ye and C. C. Li, Adv. Funct. Mater., 2020, 2001708.

12. C. Wang, J. Zhang, X. Wang, C. Lin and X. S. Zhao, Adv. Funct. Mater., 2020,

2002629.

13. J. Ma, M. Xing, L. Yin, K. San Hui and K. N. Hui, Appl. Surf. Sci., 2020, **536**, 147735.

14. Y. Ding, W. Wang, M. Bi, J. Guo and Z. Fang, Electrochim. Acta, 2019, **313**, 331-340.

15. J. Zhou, X. Liu, L. Zhu, S. Niu, J. Cai, X. Zheng, J. Ye, Y. Lin, L. Zheng and Z. Zhu, Chem, 2020, **6**, 221-233.