Electronic Supplementary Material (ESI) for Nanoscale.
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Supporting Information for

A stable layered P3/P2 and spinel intergrowth nanocomposite as long-life and high-rate cathode for sodium-ion batteries

Peiyu Hou, Jiangmei Yin, Xianhang Lu, Jiaming Li, Yue Zhao and Xijin Xu*

School of Physics and Technology, University of Jinan, Jinan, 250022, Shandong Province, China.

*E-mail: sps_xuxj@ujn.edu.cn (X. Xu)

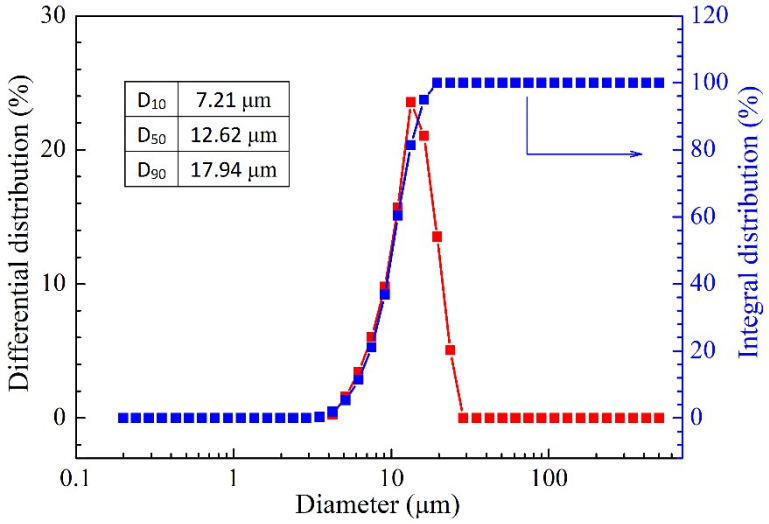

Figure S1 Particle size distribution of the as-prepared carbonate precursors $[Ni_{0.2}Co_{0.15}Mn_{0.65}]CO_3$ *via* a co-precipitation route.

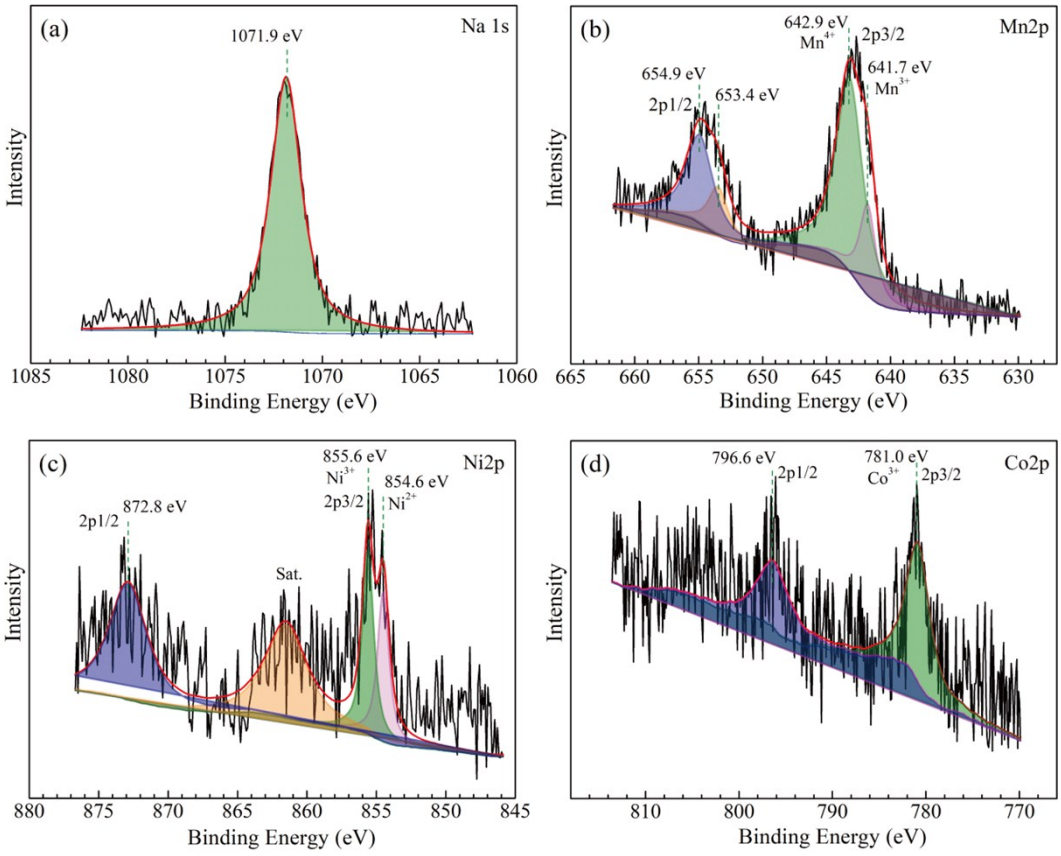

Figure S2 XPS results of the pristine layered/spinel composite: (a) Na 1s, (b) Mn 2p, (c) Ni 2p and (d) Co 2p.

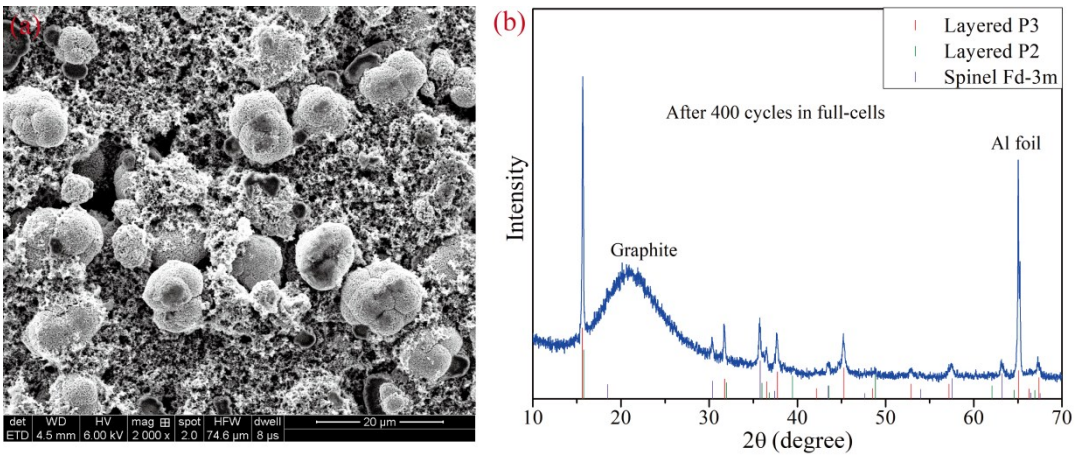

Figure S3 (a) SEM image and (b) XRD result of the cycled positive electrodes (after 400 cycles at 0.5C in full-cells) using the layered P2/P3 and Fd-3m spinel intergrowth nanocomposite as active materials.

Table S1 Comparison of electrochemical properties of sodium-ion batteries assembled by P-, O- or Fd-3m-type composite as cathodes and sodium metal or hard carbon as anodes.

Cathode	Anode	Voltage range	Capacity (mAh g^{-1})	Cycle-life	Rate capability	Ref.
P3/P2/Fd-3m composite $Na_{0.5}[Ni_{0.2}Co_{0.15}Mn_{0.65}]O_2$	Sodium metal	1.5−4.0 V	~180 (0.1C)	60.2% (400 cycles at 1C)	105 mAh g^{-1} at 10C	This work
	Hard carbon	1.5−4.0 V	~100 (0.1C)	90.6% (400 cycles at 0.5C)	56 mAh g^{-1} at 10C	
P2/Fd-3m composite $Na_{0.5}[Ni_{1/6}Co_{1/6}Mn_{2/3}]O_2$	Sodium metal	2.0−4.5 V	145 (0.2C)	~60% (100 cycles at 0.5C)	85 mAh g^{-1} at 10C	1
P3/P2 composite $Na_xNi_{0.22}Co_{0.11}Mn_{0.66}O_2$	Sodium metal	2.1−4.3 V	146.8 (0.1C)	56.7% (195 cycles at 0.1C)	~53 mAh g^{-1} at 5C	2
P3/P2 composite $Na_{0.66}Co_{0.5}Mn_{0.5}O_2$	Sodium metal	1.5−4.3 V	~180 (0.1C)	~65% (100 cycles at 1C)	86.5 mAh g^{-1} at 10C	3
P2/O3/O1 composite $Na_x[Ni_{1/3}Co_{1/3}Mn_{1/3}]O_2$	Sodium metal	2.0−4.4 V	142.8 (0.1C)	80% (100 cycles at 0.5C)	68.8 mAh g^{-1} at 5C	4
P2/O3 composite $Na_{0.7}Li_{0.3}Ni_{0.5}Mn_{0.5}O_{2+d}$	Sodium metal	2.0−4.0 V	~130 (0.1C)	~92% (10 cycles 0.1C)	~120 mAh g^{-1} at 1C	5
P2/O3 composite $Na_{0.66}Li_{0.18}[Mn_{0.71}Ni_{0.21}Co_{0.08}]O_{2+d}$	Sodium metal	1.5–4.5 V	200 (0.1C)	75% (150 cycles at 0.5C)	69 mAh g^{-1} at 5C	6
	Hard carbon	2.0–4.5 V	143 (0.1C)	–	–	
P2/O3 composite $Na_{0.67}[Li_{0.2}Mn_{0.55}Ni_{0.25}]O_2$	Sodium metal	1.5–4.2 V	158 (0.1C)	87% (50 cycles at 1C)	38 mAh g^{-1} at 8C	7

References

[1] J. Zheng, P. Yan, W. H. Kan, C. Wang, and A. Manthirama, *J. Electrochem. Soc.*, 2016, **163**(3), A584.

[2] L. G. Chagas, D. Buchholz, C. Vaalma, L. Wu and S. Passerini, *J. Mater. Chem. A*, 2014, **2**, 20263.

[3] X. Chen, X. Zhou, M. Hu, J. Liang, D. Wu, J. Wei and Z. Zhou, *J. Mater. Chem. A*, 2015, **3**, 20708.

[4] G.-L. Xu, R. Amine, Y.-F. Xu, J. Liu, J. Gim, T. Ma, Y. Ren, C.-J. Sun, Y. Liu, X. Zhang, S. M. Heald, A. Solhy, I. Saadoune, W. L. Mattis, S.-G. Sun, Z. Chen and K. Amine, *Energy Environ. Sci.*, 2017, **10**, 1677.

[5] E. Lee, J. Lu, Y. Ren, X. Luo, X. Zhang, J. Wen, D. Miller, A. DeWahl, S. Hackney, B. Key, D. Kim, M. Slater and C. Johnson, *Adv. Energy Mater.*, 2014, **4**, 1400458.

[6] S. Guo, P. Liu, H. Yu, Y. Zhu, M. Chen, M. Ishida and H. Zhou, *Angew. Chem. Int. Ed.*, 2015, **54**, 5894–5899.

[7] Z.-Y. Li, J. Zhang, R. Gao, H. Zhang, L. Zheng, Z. Hu and X. Liu, *J. Phys. Chem. C*, 2016, **120**, 9007–9016.