Electronic Supplementary Material (ESI) for Chemical Science.
This journal is © The Royal Society of Chemistry 2022

Supporting Information

Rapid Synthesis of Layered K_xMnO_2 Cathodes from Metal-Organic Frameworks for Potassium-Ion Batteries

Ang Li, [a†] Changfeng Li, [a†] PeiXun Xiong, [a†] Jinfeng Zhang, [a] Dongling Geng, [b] and Yunhua Xu* [a]

[a] School of Materials Science and Engineering, Key Laboratory of Advanced Ceramics and Machining Technology (Ministry of Education), and Tianjin Key Laboratory of Composite and Functional Materials, Tianjin University, Tianjin 300072, China.

[b] School of Materials Science and Engineering, Nanjing University of Science and Technology, 200 Xiaolingwei, Nanjing 210094, P. R. ChinaAddress here.

[†] Ang Li, Changfeng Li and Peixun Xiong contributed equally to this work.

* Author for correspondence

E-mail: yunhua.xu@tju.edu.cn

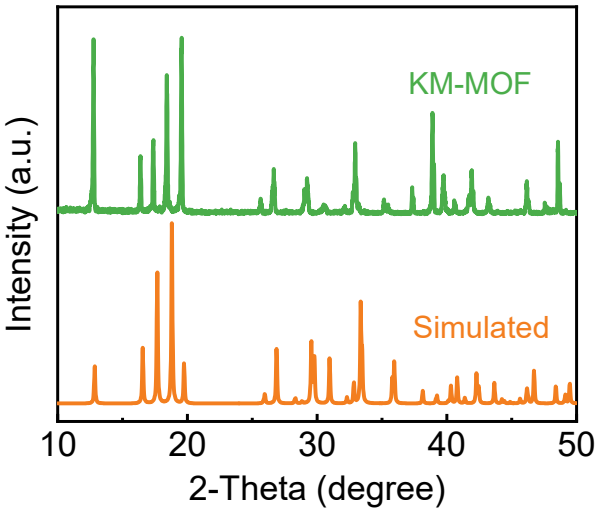

Fig. S1 XRD pattern of KM-MOF.

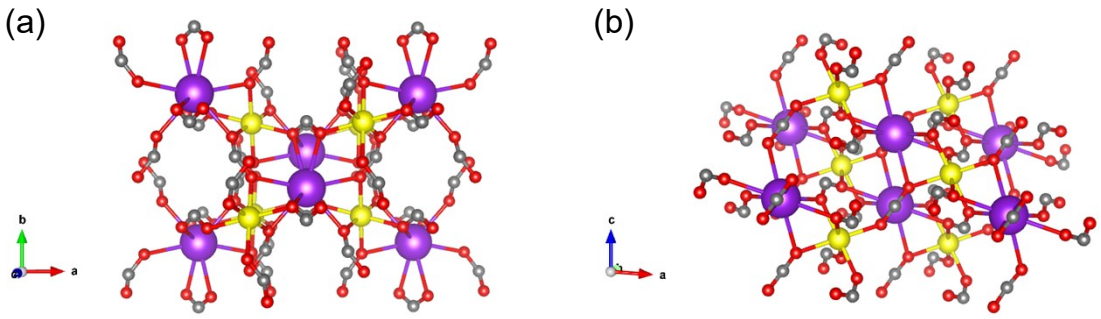

Fig. S2 3D structures of KM-MOF along (a) c and (b) b directions. (Mn: yellow, K: purple, C: gray, and O: red).

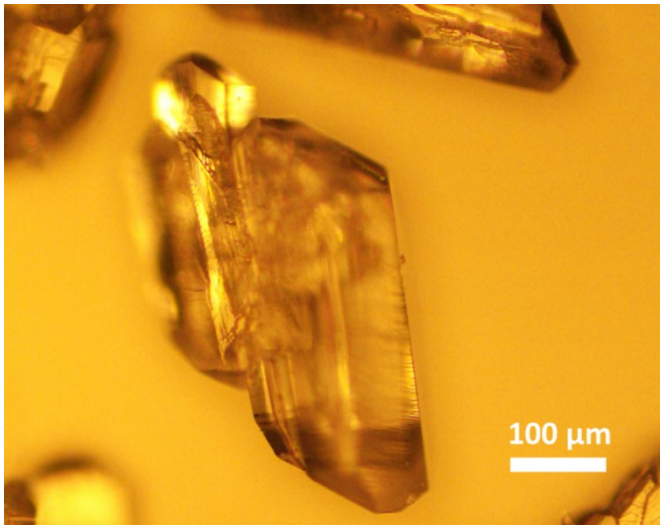

Fig. S3 Optical microscope photograph image of KM-MOF.

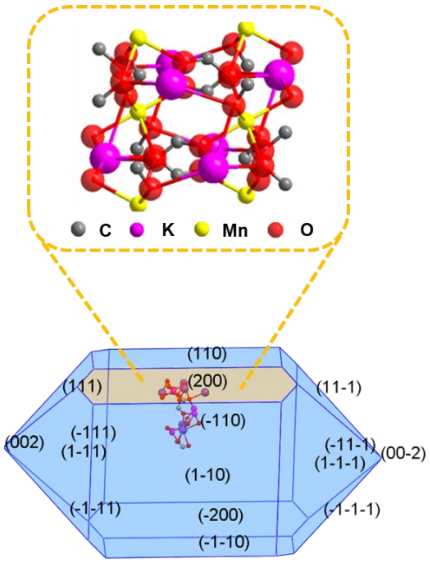

Fig. S4 Crystal structure on the view of (200) plane of KM-MOF.

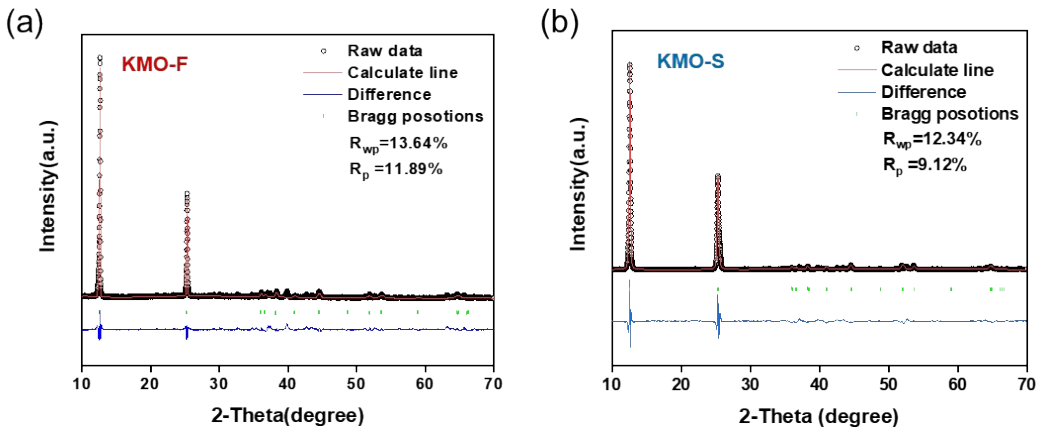

Fig. S5 XRD patterns and Rietveld refinement plots of (a) KMO-F and (b) KMO-S.

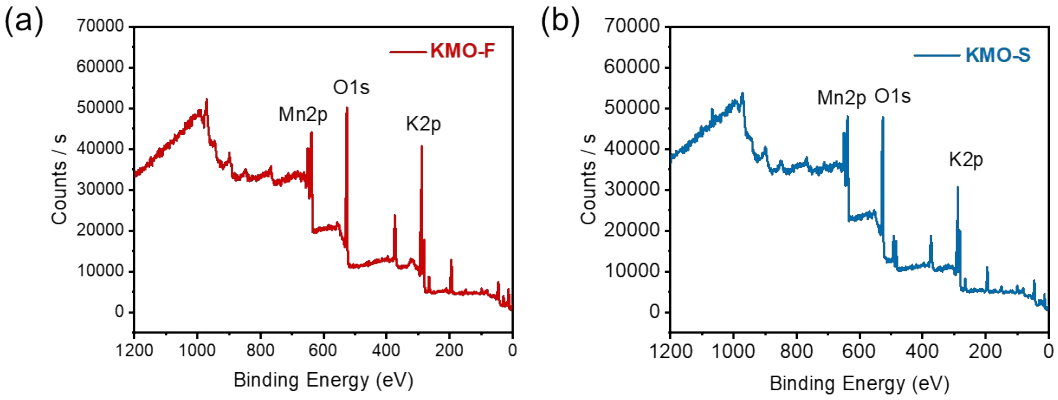

Fig. S6 Full XPS survey scans of (a) KMO-F and (b) KMO-S.

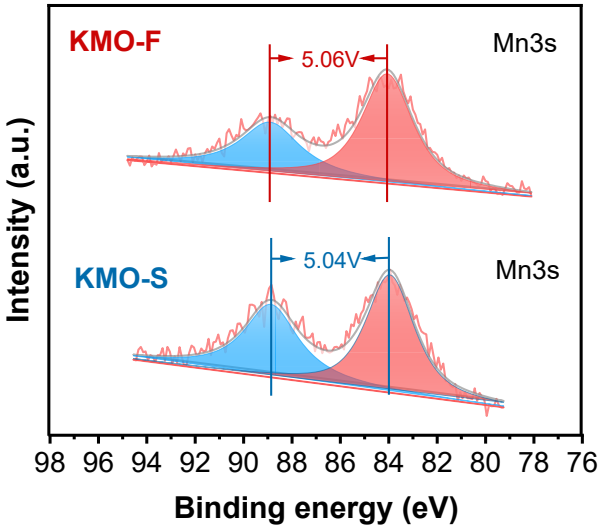

Fig. S7 XPS spectra of Mn 3s and compositional analyse for KMO-F and KMO-S.

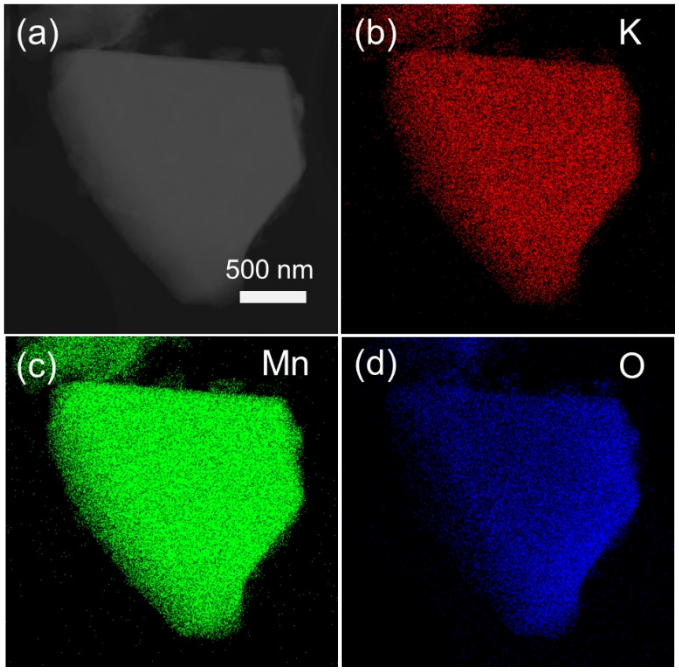

Fig. S8 STEM image of KMO-S and elemental mappings of K, Mn, and O.

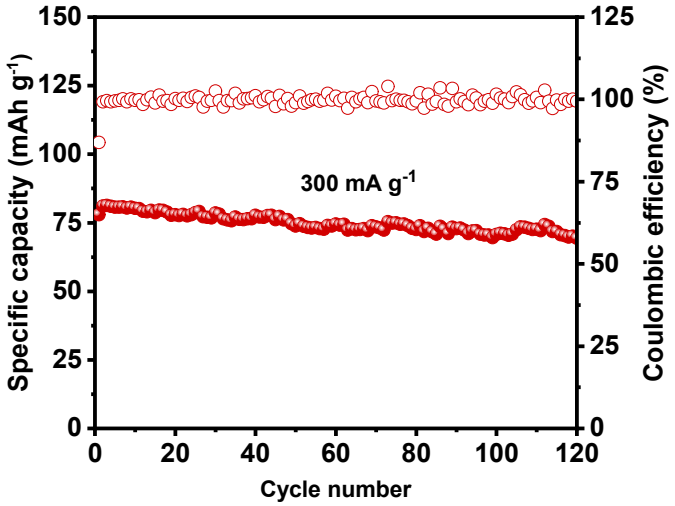

Fig. S9 Cycling performance of KMO-F at 300 mA g^{-1} in the voltage range of 2.0-4.2V.

Tab. S1 Comparison of reaction conditions for preparing layered K_xMnO_2 in this work and the literature.

Layered Oxides	Synthesis methods	Calcination temperature and time	References
KMO-F	**Thermal decomposition of MOFs**	**1000 °C@8 min**	**This work**
P3-Type $K_{0.5}MnO_2$	Solid state	800 °C@12 h	1
$K_{0.45}Mn_{1-x}Fe_xO_2$	Solid state	850 °C@15 h	2
P2-$K_{0.44}Ni_{0.22}Mn_{0.78}O_2$	Solid state	1000 °C@30 h	3
P3- $K_{0.48}Mn_{0.4}Co_{0.6}O_2$	Solid state	850 °C@2 h	4
$K_{0.54}Mn_{0.78}Mg_{0.22}O_2$	Solid state	800 °C@10 h	5
$K_{0.6}Mn_{0.8}Ni_{0.1}Ti_{0.1}O_2$	Solid state	1000 °C@15 h	6
P2-KMO	Sol-gel method	950 °C@24h	7
K_xMnO_2	Co-precipitation	900 °C@15 h	8
P2-$K_{0.75}[Ni_{0.3}Mn_{0.7}]$ O_2	Co-precipitation	900 °C@10 h	9
$K_xMn_{0.7}Ni_{0.3}O_2$	Co-precipitation	900 °C@10 h	10

Tab. S2 Comparison of electrochemical performances of LTMOs in KIBs in this work and the literature.

Layered oxides	Discharge capacity (mAh g^{-1})	Cycle performance (capacity retention@cycles)	Rate performance (mAh g^{-1}@mA g^{-1})	References
KMO-F	**126.6**	**80%@100**	**64@1000**	**This work**
KMO-S	**119.5**	**85%@100**	**72@1000**	**This work**
P3-$K_{0.5}MnO_2$	100	70%@50	38@100	1
P3- $K_{0.45}MnO_2$	129	70.8%@100	51@200	8
P2- $K_{0.3}MnO_2$	117	61.1%@100	48@200	8
P2- $K_{0.67}MnO_2$	78	90.5%@300	78@200	7
$K_{0.77}MnO_2{\cdot}0.23H_2O$	125	93%@100	77@1000	11
P2-$K_{0.44}Ni_{0.22}Mn_{0.78}O_2$	82	67%@500	58@500	3
P2-$K_{0.75}Mn_{0.8}Ni_{0.1}Fe_{0.1}O_2$	80	70%@200	62@1000	12
P3- $K_{0.48}Mn_{0.4}Co_{0.6}O_2$	48	82%@30	24@119	4
P'3- $K_{0.3}Mn_{0.9}Cu_{0.1}O_2$	124	82%@50	64@500	13

Tab. S3 Summary of bond lengths in KM-MOF.

Bonds	Bond Lengths (Å)
Mn-O	2.190(1) *2, 2.177(1) *2, 2.173(1), 2.109(1) *2
K-O	2.834(1) *1, 2.859(1) *2, 2.834 (1) *2, 2.751(1) *1

Tab. S4 ICP-AES test results of layered K_xMnO_2.

Products	**x values**	**Atomic ratios of K : Mn**
KMO-F	0.53	0.526 : 1
KMO-S	0.51	0.514 : 1

Tab. S5 Compositional analyses from Mn3s XPS spectra of KMO-F and KMO-S.

Products	**ΔE3s (eV)**	**Valences of Mn**
KMO-F	5.06	3.47
KMO-S	5.04	3.49

References

1. H. Kim, D.-H. Seo, J. C. Kim, S.-H. Bo, L. Liu, T. Shi and G. Ceder, *Adv. Mater.*, 2017, **29**, 1702480.
2. C.-l. Liu, S.-h. Luo, H.-b. Huang, X. Liu, Y.-c. Zhai and Z.-w. Wang, *Chem. Eng. J.* , 2019, **378**, 122167.
3. X. Zhang, Y. Yang, X. Qu, Z. Wei, G. Sun, K. Zheng, H. Yu and F. Du, *Adv. Funct. Mater.*, 2019, **29**, 1905679.
4. K. Sada and P. Barpanda, *Chem. Commun.*, 2020, **56**, 2272-2275.
5. R. Huang, Q. Xue, J. Lin, X. Zhang, J. Zhou, F. Wu, L. Li and R. Chen, *Nano Res.*, 2022, **15**, 3143-3149.
6. Y.-S. Xu, Y.-N. Zhou, Q.-H. Zhang, M.-Y. Qi, S.-J. Guo, J.-M. Luo, Y.-G. Sun, L. Gu, A.-M. Cao and L.-J. Wan, *Chem. Eng. J.* , 2021, **412**, 128735.
7. K. Lei, Z. Zhu, Z. Yin, P. Yan, F. Li and J. Chen, *Chem*, 2019, **5**, 3220-3231.
8. C.-l. Liu, S.-h. Luo, H.-b. Huang, Y.-c. Zhai and Z.-w. Wang, *Chem. Eng. J.* , 2019, **356**, 53-59.
9. J. H. Jo, J. U. Choi, Y. J. Park, Y. H. Jung, D. Ahn, T.-Y. Jeon, H. Kim, J. Kim and S.-T. Myung, *Adv. Energy Mater.*, 2020, **10**, 1903605.
10. Z. Xiao, J. Meng, F. Xia, J. Wu, F. Liu, X. Zhang, L. Xu, X. Lin and L. Mai, *Energy Environ. Sci.*, 2020, **13**, 3129-3137.
11. B. Lin, X. Zhu, L. Fang, X. Liu, S. Li, T. Zhai, L. Xue, Q. Guo, J. Xu and H. Xia, *Adv. Mater.* , 2019, **31**, 1900060.
12. J.-Y. Hwang, J. Kim, T.-Y. Yu, H.-G. Jung, J. Kim, K.-H. Kim and Y.-K. Sun, *J. Mater. Chem. A*, 2019, **7**, 21362-21370.
13. S. Park, S. Park, Y. Park, M. H. Alfaruqi, J.-Y. Hwang and J. Kim, *Energy Environ. Sci.*, 2021, **14**, 5864-5874.