Electronic Supplementary Information

Experimental section

Synthesis of materials

0.8 g of LiF was dissolved in HCl (10 mL, 9 M) to obtain a uniform solution. 0.5 g of Ti_3AlC_2 was added into the solution and left under stirring for 24 h at 40 °C to etch the Al element. Then the mixture was centrifugated and washed with deionized water many times until the pH was up to 6. The multilayered $Ti_3C_2T_x$ precipitate was collected after removing the acidic supernatant.

The obtained $Ti_3C_2T_x$ MXene was added into LiOH (20 mL, 1 M) and left to stand for 24 h. After washing with deionized water, the precipitate was transferred to $Mn(NO_3)_2$ (20 mL, 1 M) solution, then stirred for 12 h in the oxygen atmosphere. Subsequently, the precipitate was centrifugated and washed using deionized water. Finally, the Mn–$Ti_3C_2T_x$ was obtained after drying in the vacuum at 60 °C.

Material characterization

The scanning electron microscopy (SEM) images were observed by JSM-7800F. The transmission electron microscopy (TEM) images were obtained by JEM-2100. The X-ray diffraction (XRD) tests were carried out on the Rigaku Ultima IV. The X-ray photoelectron spectroscopy (XPS) tests were conducted by Thermo Scientific ESCALAB Xi+.

Electrochemical measurements

The electrochemical measurements were performed using CR2025-type coin cells. The active materials, carbon black, and polyvinylidene fluoride were mixed in the N-Methyl-pyrrolidone solution at a mass ratio of 8:1:1, and they were stirred for 24 h. Subsequently, the mixture was coated on the titanium foil and dried in the vacuum at 60 ℃ for 12 h. The mass loading was 1 mg cm^{-2}. The 2 M

$ZnSO_4$ + 0.2 M $MnSO_4$ served as the aqueous electrolyte. The galvanostatic discharge-charge profiles and cycling performances were recorded on a Land CT2001A system. The Cyclic voltammetry (CV) and electrochemical impedance spectroscopy (EIS) tests were carried out by the electrochemical workstation (CHI 660E).

First-principles calculations

The DFT calculations were performed using the Vienna Ab-initio Simulation Package (VASP) with the Projector Augmented Wave method. The energy cutoff was set to 450 eV. The *k*-point mesh of 3×3×1 was used for these calculations. The energy convergence threshold was set to 10^{-5} eV.

Table S1. The comparison of the electrochemical performance between Mn–$Ti_3C_2T_x$ MXene and other MXene cathodes for RAZBs.

Cathode material	Discharge plateau (vs. Zn)	Capacity and cycling stability	Ref.
Mn–$Ti_3C_2T_x$ MXene	1.4 V	0.3 A g^{-1}/100 cycle/143 mAh g^{-1} 5 A g^{-1}/1000 cycle/65 mAh g^{-1}	This work
MnO_x@$Ti_3C_2T_x$	1.4 V	5 A g^{-1}/400 cycle/50 mAh g^{-1}	1
Sn^{4+}-Ti_2CT_x/C	–	0.1 A g^{-1}/130 cycles/138 mAh g^{-1}	2
$Ti_3C_2Br_2$	1.6 V	4 A g^{-1}/1000 cycles/60 mAh g^{-1}	3
$Ti_3C_2I_2$	1.1 V	4 A g^{-1}/700 cycles/70 mAh g^{-1}	3
MoO_{3-x}/MXene	0.8 V	4 A g^{-1}/1600 cycles/52 mAh g^{-1}	4

References

1. S. Luo, L. Xie, F. Han, W. Wei, Y. Huang, H. Zhang, M. Zhu, O. G. Schmidt and L. Wang, Advanced Functional Materials, 2019, **29**, 1901336.
2. X. Li, M. Li, Q. Yang, D. Wang, L. Ma, G. Liang, Z. Huang, B. Dong, Q. Huang and C. Zhi, Advanced Energy Materials, 2020, **10**, 2001394.
3. M. Li, X. Li, G. Qin, K. Luo, J. Lu, Y. Li, G. Liang, Z. Huang, J. Zhou, L. Hultman, P. Eklund, P. O. Å. Persson, S. Du, Z. Chai, C. Zhi and Q. Huang, ACS Nano, 2021, **15**, 1077-1085.
4. J. Shi, Y. Hou, Z. Liu, Y. Zheng, L. Wen, J. Su, L. Li, N. Liu, Z. Zhang and Y. Gao, Nano Energy, 2022, **91**, 106651.