Electronic Supplementary Material (ESI) for Nanoscale

Supporting Information

Construction of hierarchical V_4C_3-MXene/MoS_2/C nanohybrids for high rate lithium-ion batteries

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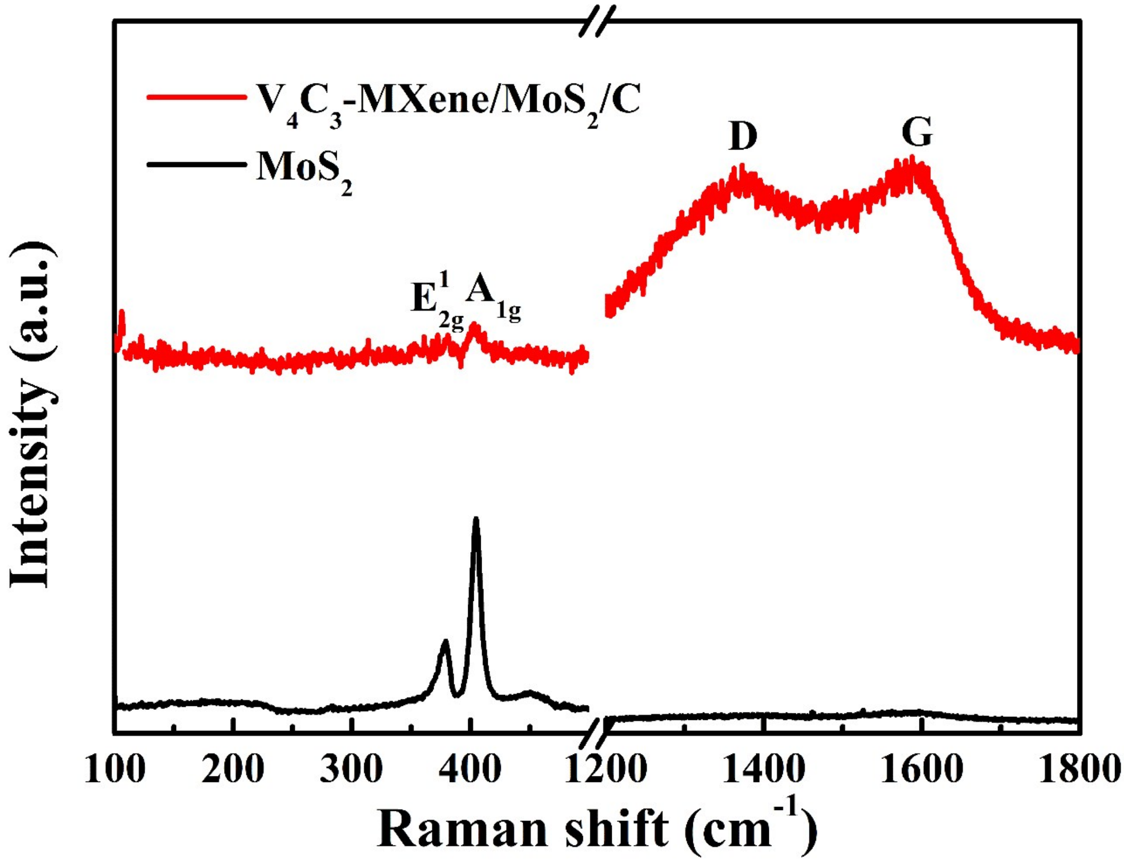

Fig. S1. Raman spectra of the MoS_2 and V_4C_3-MXene/MoS_2/C nanohybrid.

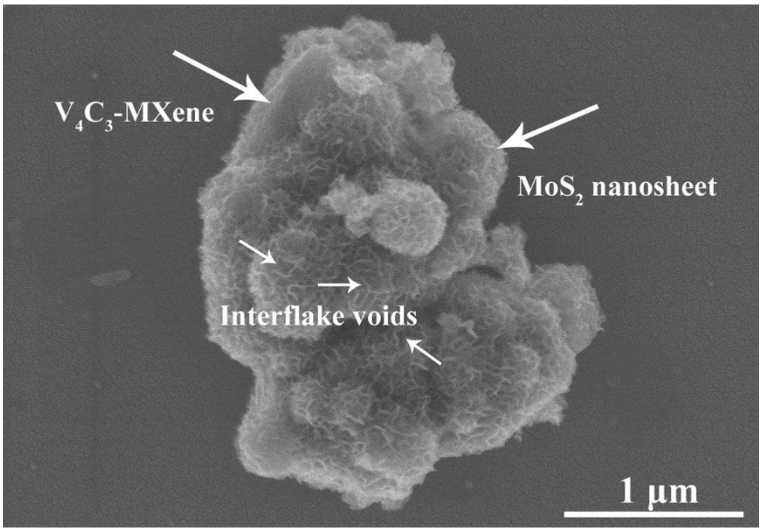

Fig. S2. SEM image of V_4C_3-MXene exposed from MoS_2 layer in the V_4C_3-MXene/MoS_2/C nanohybrid.

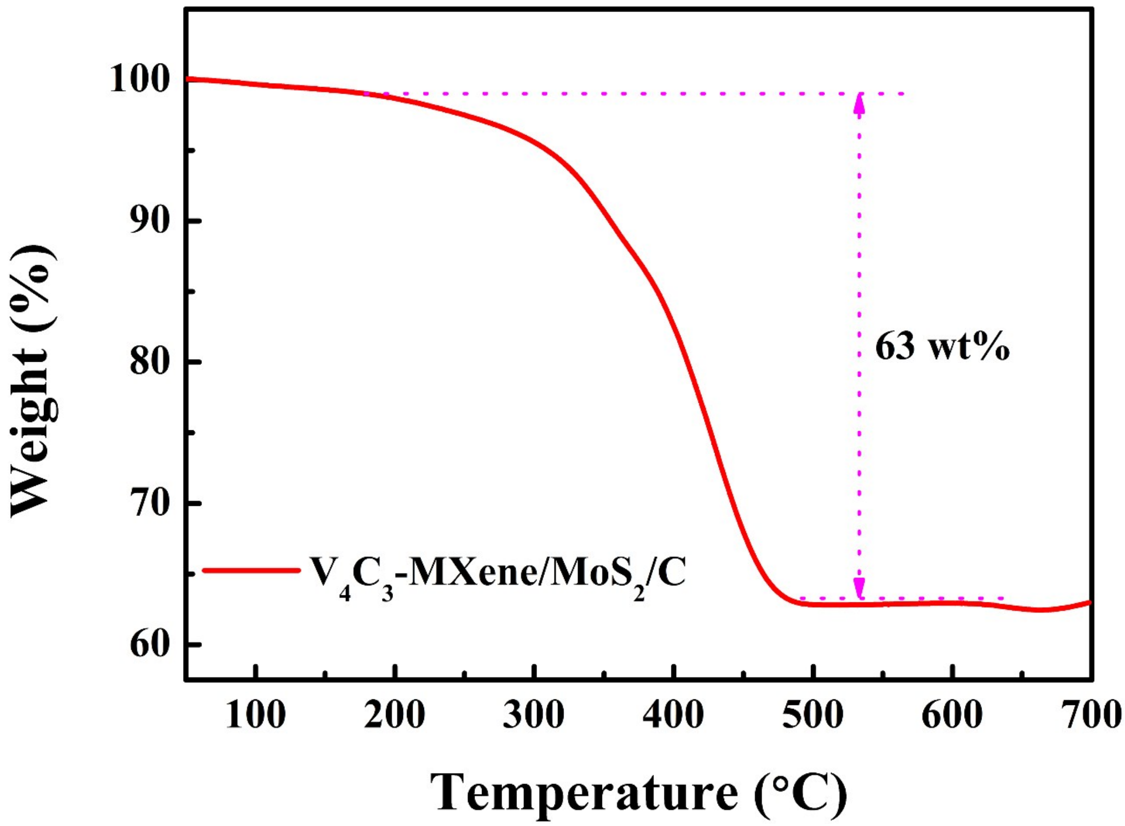

Fig. S3. TGA curve of the V_4C_3-MXene/MoS_2/C nanohybrid.

Detailed process about TGA calculation: In the temperature range from 50 to 700 °C in air, the main weight loss is composed of three parts: the oxidation of the N-doped carbon and the oxidation of MoS_2 and V_4C_3-MXene. The total weight loss is about 37 wt% according to the TGA curve shown in Fig. S3. Assumed to the final product is composed of MoO_3 and V_2O_5, the corresponding reaction processes are as follows:

$$MoS_2 + O_2 \rightarrow MoO_3 + SO_2 \quad (1)$$

$$V_4C_3\text{-MXene} + O_2 \rightarrow V_2O_5 \quad (2)$$

$$C + O_2 \rightarrow CO_2 \quad (3)$$

Assumed to molar mass of $MoS_2 = M_1$, molar mass of $MoO_3 = M_2$, molar mass of V_4C_3-MXene = M_3, molar mass of $V_2O_5 = M_4$, the weight content of the nanohybrid = X, the content of MoS_2 in the nanohybrid = m_1, the content of $MoO_3 = m_2$, the content of V_4C_3-MXene in the nanohybrid = m_3, the content of $V_2O_5 = m_4$, and the content of carbon in the nanohybrid = m_5,

Due to the final product is MoO_3 and V_2O_5, so $m_2 + m_4 = 0.63X$.

According to Equation (1) and (2), $m_1 = m_2/M_2*M_1$, $m_3 = m_4/M_4*M_3$,

Thus, a new equation $0.89m_1 + 0.76m_3 = 0.63X$ *can be obtained.*

According to the results of EDS and ICP, $m_1 \approx 7m_3$,

Thus, $m_1 = 0.63X$, $m_3 = 0.09X$, $m_5 = X - m_1 - m_3 = 0.28X$.

So, the carbon content in the nanohybrid is about 28 wt%.

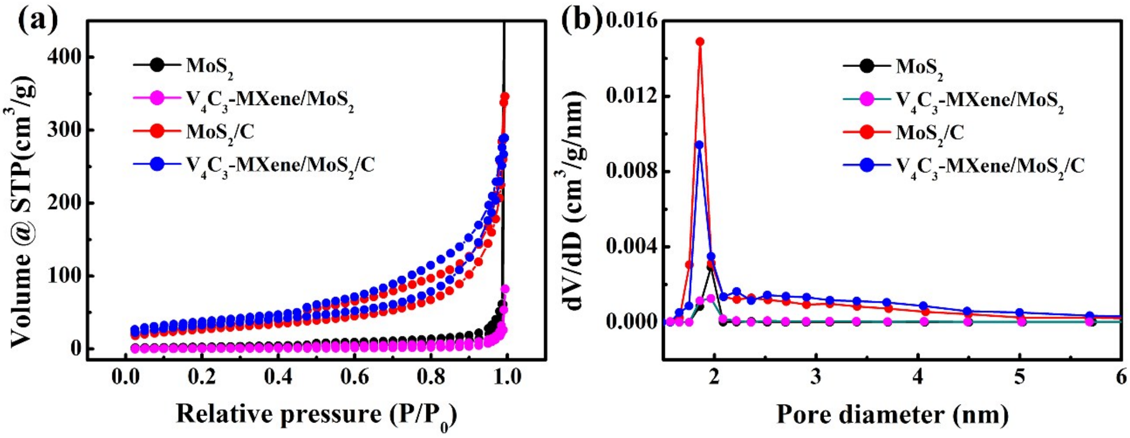

Fig. S4. (a) N_2 adsorption and desorption isotherms and (b) pore size distributions of MoS_2, MoS_2/C, V_4C_3-MXene/MoS_2, and V_4C_3-MXene/MoS_2/C nanohybrid.

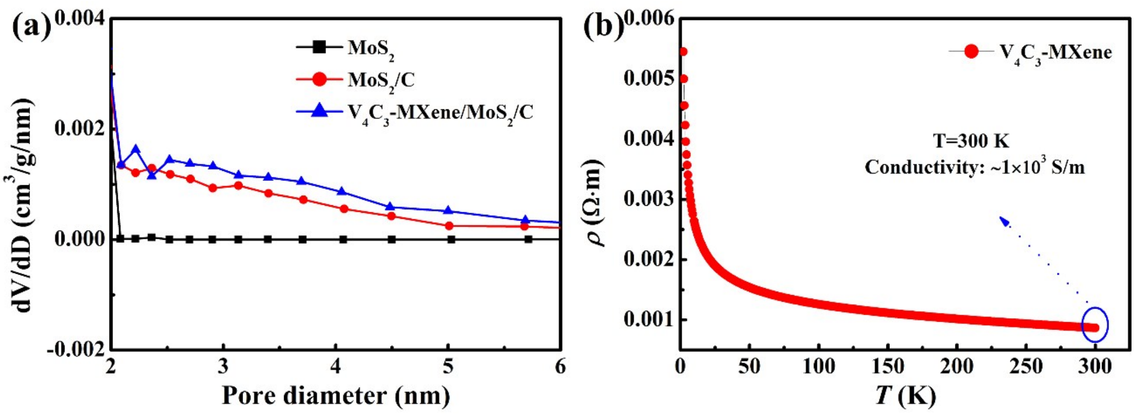

Fig. S5. (a) The magnified pore size distribution of the MoS_2, MoS_2/C, and V_4C_3-MXene/MoS_2/C samples. (b) Temperature dependence of resistivity $\rho(T)$ for the V_4C_3-MXene matrix.

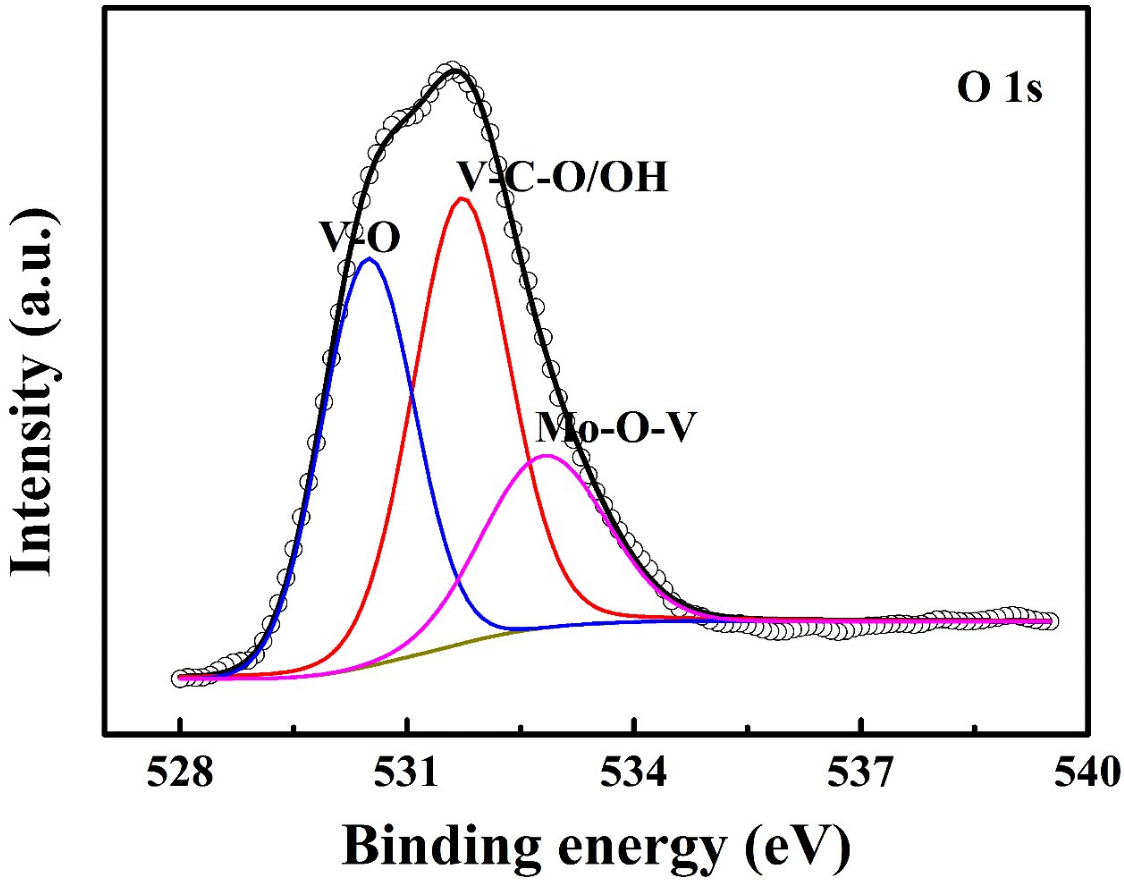

Fig. S6. XPS spectrum of O1s in the V_4C_3-MXene/MoS_2/C nanohybrid.

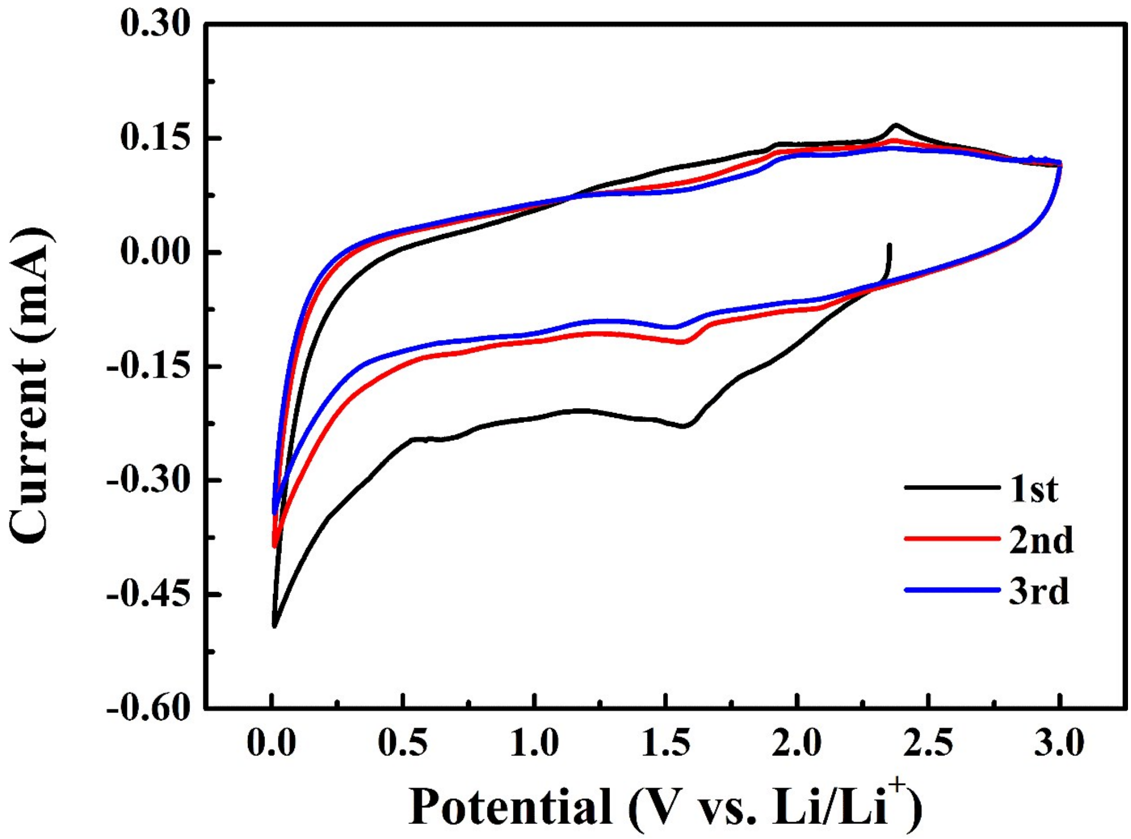

Fig. S7. CV curves of V_4C_3-MXene electrode for the first three cycles at 0.1 mV s^{-1}.

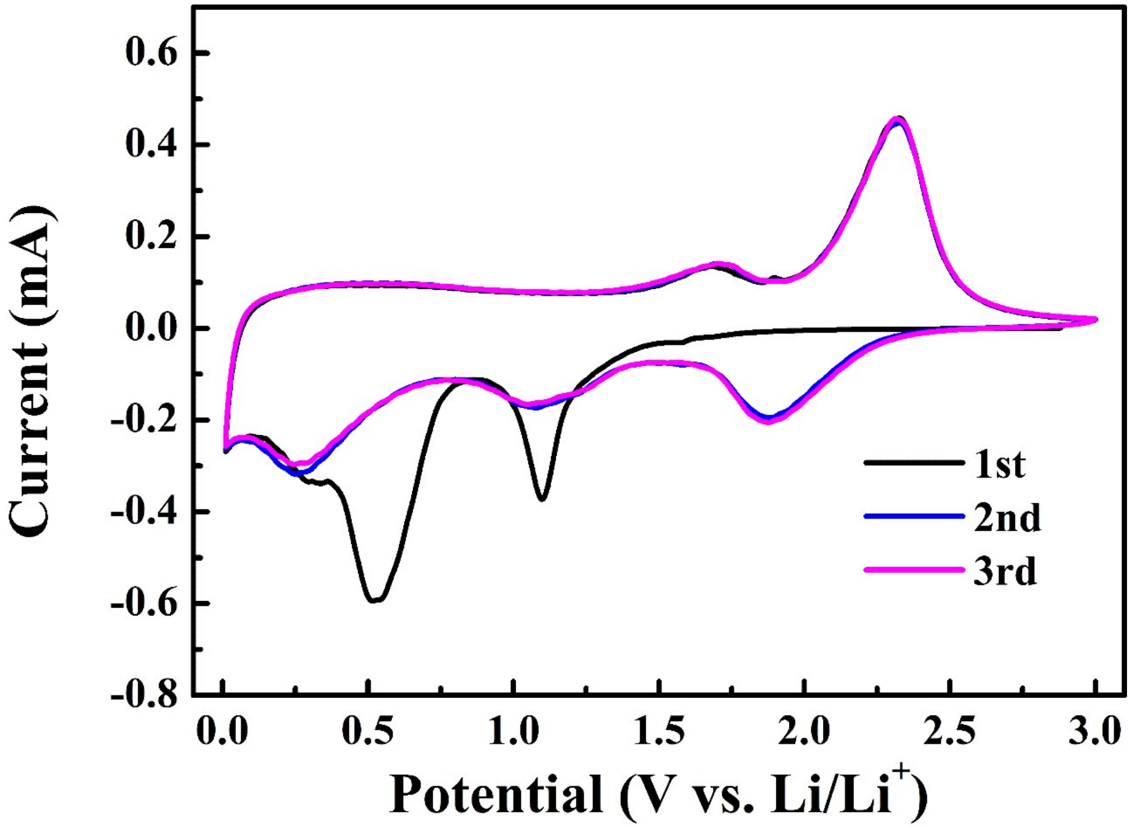

Fig. S8. CV curves of MoS_2 electrode for the first three cycles at 0.1 mV s^{-1}.

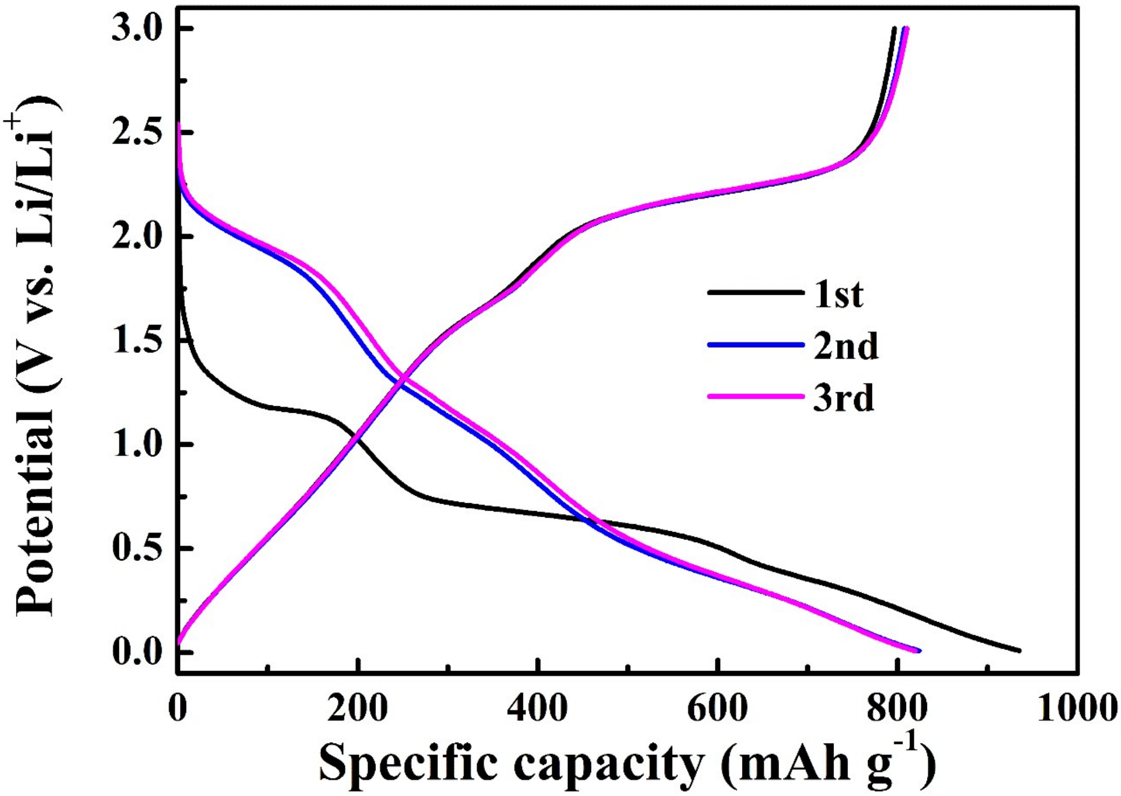

Fig. S9. Galvanostatic discharge and charge profiles of MoS_2 electrode for the first three cycles at 0.1 A g^{-1}.

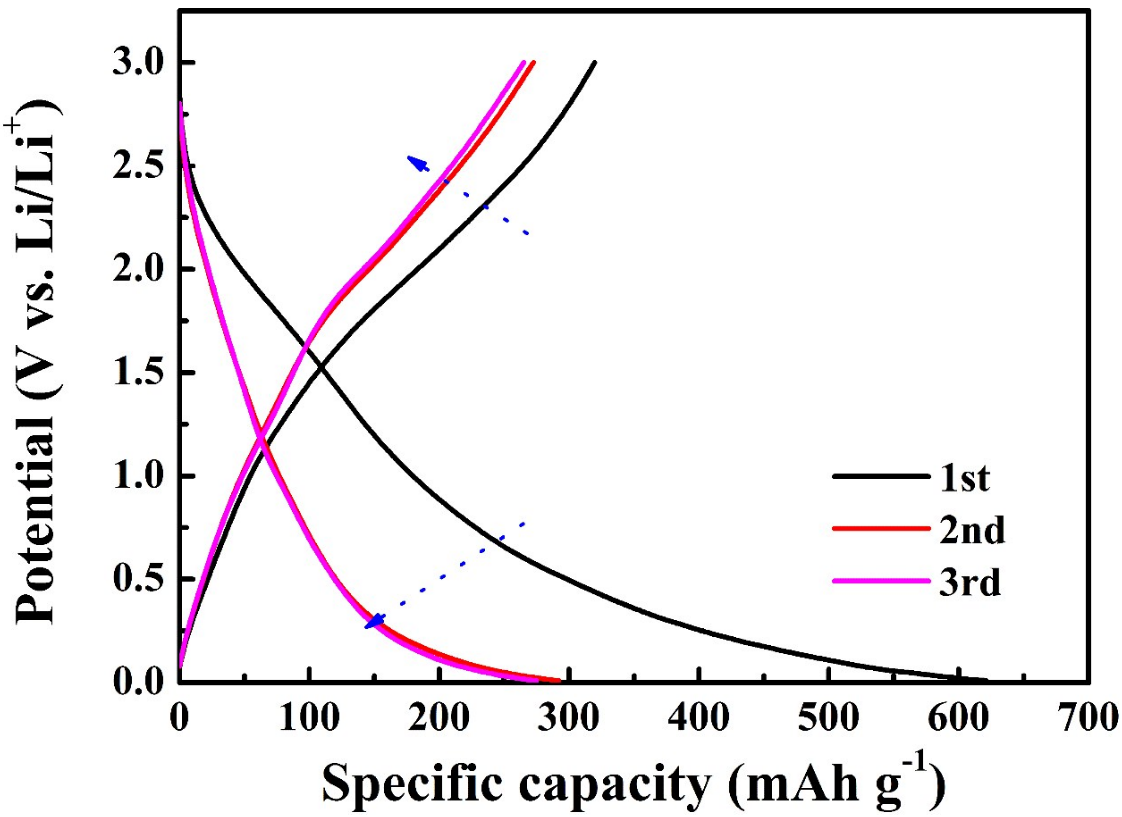

Fig. S10. Galvanostatic discharge and charge profiles of V_4C_3-MXene electrode for the first three cycles at 0.1 A g^{-1}.

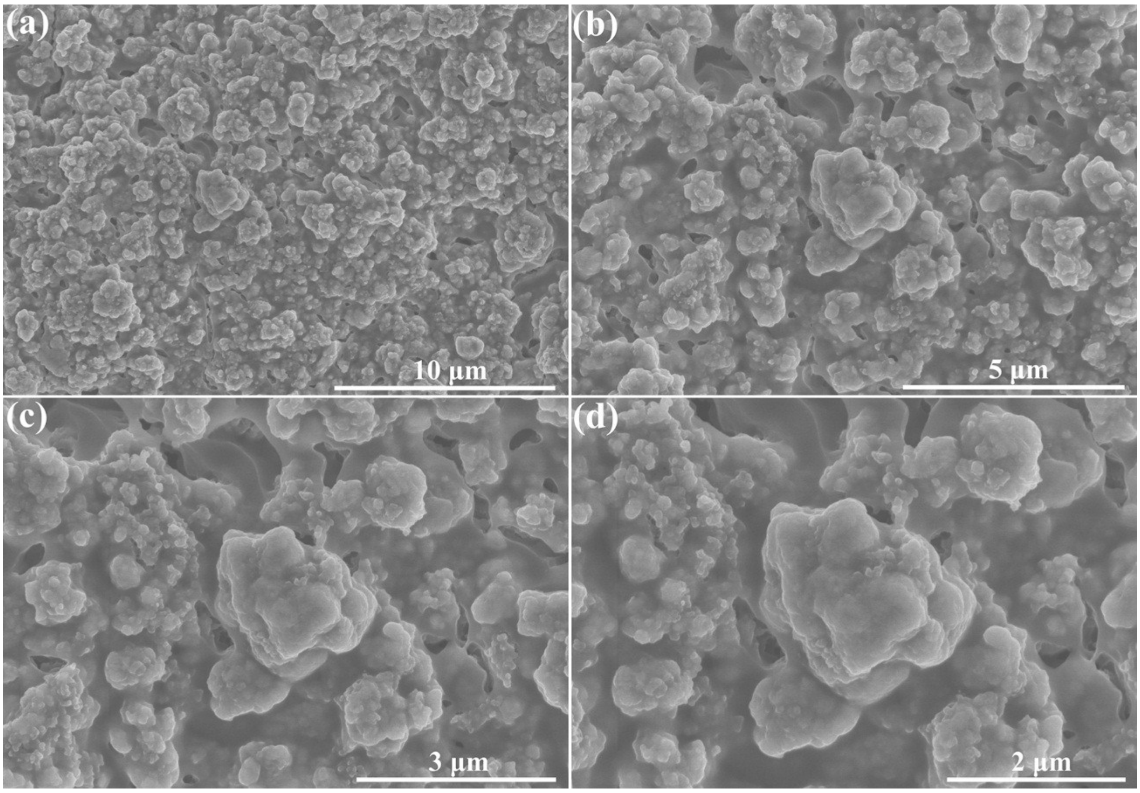

Fig. S11. The SEM images of the V_4C_3-MXene/MoS_2/C nanohybrid electrode after 450 cycles at 1 A g^{-1} at the different magnifications.

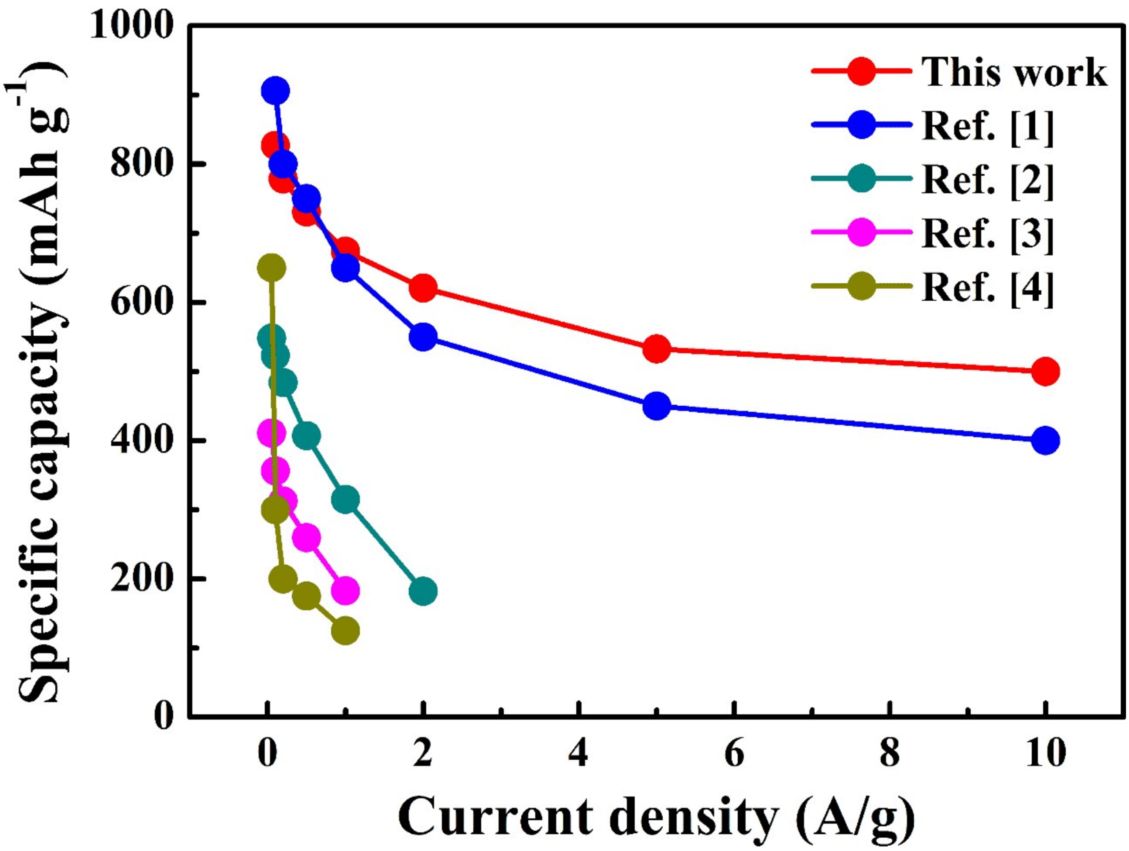

Fig. S12. The comparison of the rate performance of the V_4C_3-MXene/MoS_2/C with recently reported MXene/MoS_2 composite materials in the lithium storage performance.

Table S1. The comparison of the element content for the V_4C_3-MXene/MoS_2/C nanohybrid derived from the ICP-MS and EDS analysis.

Elements	EDS (wt%)	ICP-MS (wt%)
Mo	42.73	42.8
V	8.09	8.2

Table S2. N_2 adsorption/desorption results of the four studied samples.

Samples	Surface area (m^2/g)	Main pore size (nm)	Pore volume (cc/g)
MoS_2	9.4	1.96	0.050
V_4C_3-MXene/MoS_2	12.5	1.96	0.131
MoS_2/C	95.8	1.87	0.284
V_4C_3-MXene/MoS_2/C	116.0	1.86	0.319

Table S3. The comparison of R_{ct}, σ, and D_{Li^+} for different electrodes.

Electrodes	R_{ct} (Ω)	σ	D_{Li^+} (cm^2/s)
MoS_2	259.4	504.4	5.7×10^{-18}
MoS_2@C	153.5	202.0	3.6×10^{-18}
V_4C_3-MXene/MoS_2	105.8	89.7	1.8×10^{-17}
V_4C_3-MXene/MoS_2/C	67.8	36.2	1.1×10^{-16}

References

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