

Electronic Supplementary Information

MXene-based aerogel with cobalt nanoparticles as an efficient sulfur host for room-temperature Na-S batteries

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1. Material characterization

The morphologies and structures of the prepared aerogels were examined by FESEM (JSM-7800F, Japan) and TEM (JEM-2100, Japan). EDS mapping was used to analyze the elemental composition and distribution of the product. The crystal structures were recorded through XRD (MAXima-X XRD-7000, Cu K α radiation, $\lambda=1.5416$ Å). HR Evolution (Horiba) with 532 nm laser was used to collect Raman spectrum. In-situ Raman was recorded by jointing EL-CELL (Germany) and CHI 760E on the basis of ex-situ Raman. The specific surface area and pore volume were measured by BET (Quadrachrome evo 2QDS-MP-30). The sulfur content was acquired from TGA (Q50, USA) under nitrogen atmosphere. The elemental composition of the material was tested by XPS (ESCALAB 250Xi electron spectrometer, Thermo Scientific). UV-Vis spectra were obtained by a Shimadzu UV-2550 spectrophotometer.

2. Electrochemical measurements

The electrochemical performances of MG-Co@S were explored by assembling CR2032 cells with Na metal as the counter electrode in the glove box. The working electrodes were fabricated by slurry coating method. In detail, MG-Co@S, polyvinylidene fluoride and acetylene black were mixed in the mass ratio of 8:1:1 with an appropriate amount N-methyl-2-pyrrolidone. After the slurry was uniformly coated on the aluminum foil, it was dried at 60 °C for 12 h under vacuum. The electrolyte was 1.0 M NaPF₆ dissolved in 1,3-dioxolane (DOL) and Diethylene glycol

dimethyl ether (DIGLYME) (1 : 1 Vol%). The separator was glass fiber membrane (Whatman GF/A). All specific capacity calculations were based on the mass of sulfur ($1\text{ C} = 1675\text{ mA h g}^{-1}$). Cyclic voltammetry (CV) curves were recorded by CHI 760E (Shanghai Chenhua, China) with a scan rate of 0.1 mV s^{-1} . The galvanostatic charge/discharge test was conducted by Land battery test system (CT2001A, Wuhan Kingnuo Electronic Co., China) in the voltage range of 0.5 - 2.8 V (vs. Na/Na⁺) after 8 hours of standing. EIS was tested by Zennium electrochemical workstation.

Supplementary Figures

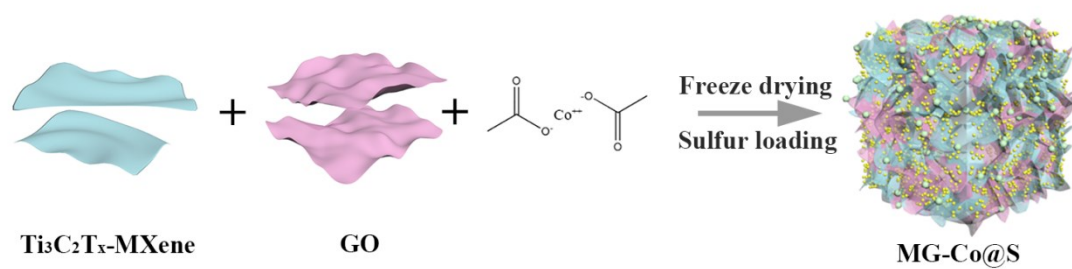


Figure. S1 Illustration for the preparation of MG-Co@S composite.

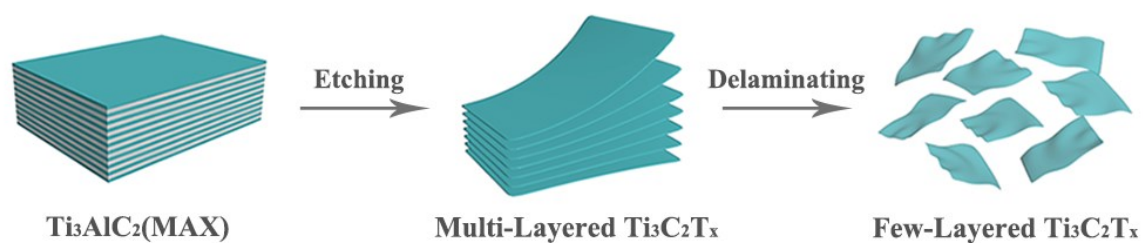


Figure. S2 Illustration of the exfoliated process of the few-layered $\text{Ti}_3\text{C}_2\text{T}_x$.

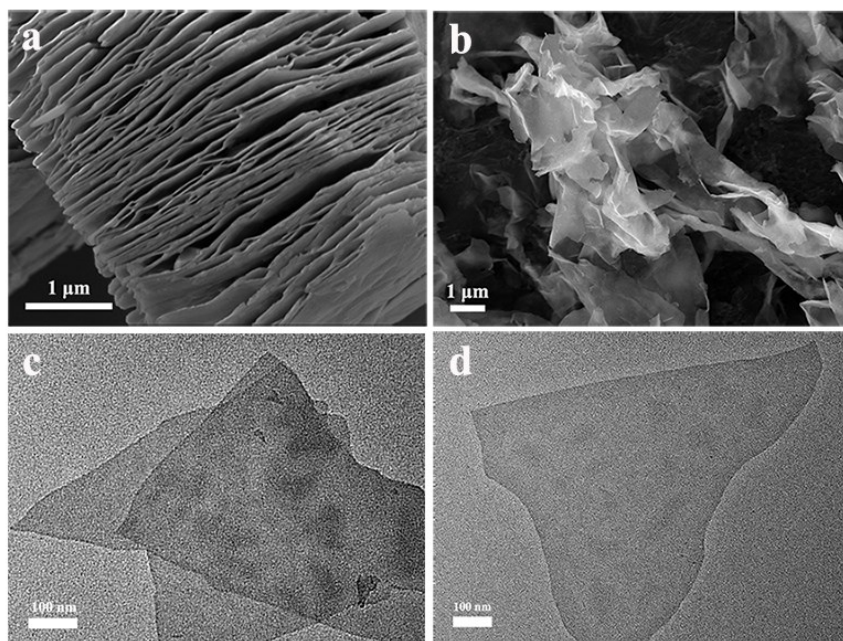


Figure S3 (a) SEM image of $\text{Ti}_3\text{C}_2\text{T}_x$ MXene before delamination; (b) SEM and (c-d) TEM images of $\text{Ti}_3\text{C}_2\text{T}_x$ MXene flakes after delamination under ultrasonic.

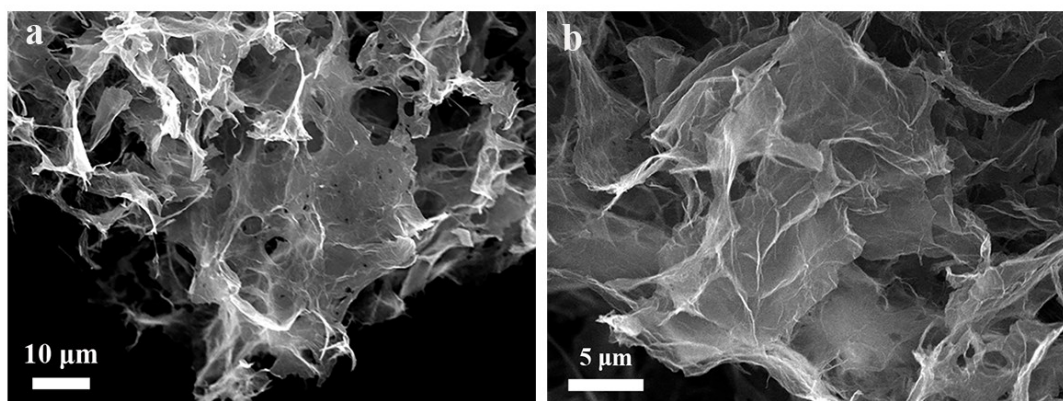


Figure S4 (a) SEM images of MG.

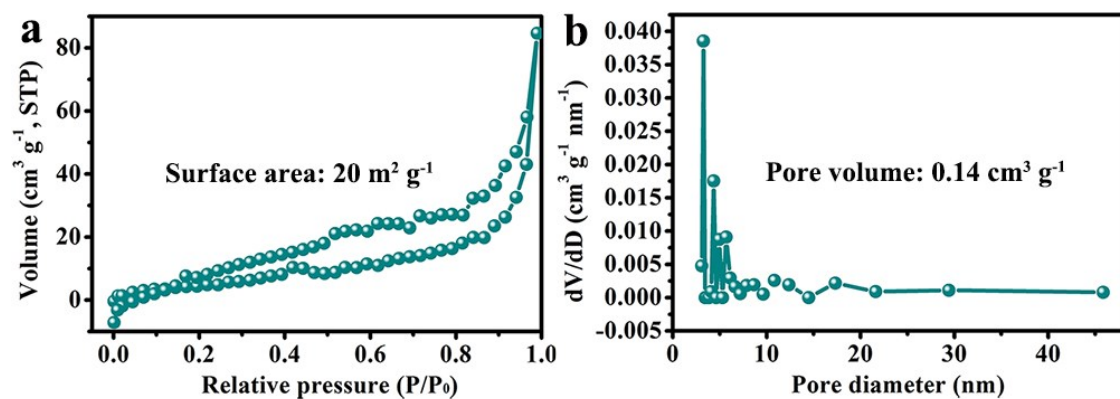


Figure S5 (a) N_2 adsorption and desorption curves and (b) pore size distribution curve of pure $Ti_3C_2T_x$.

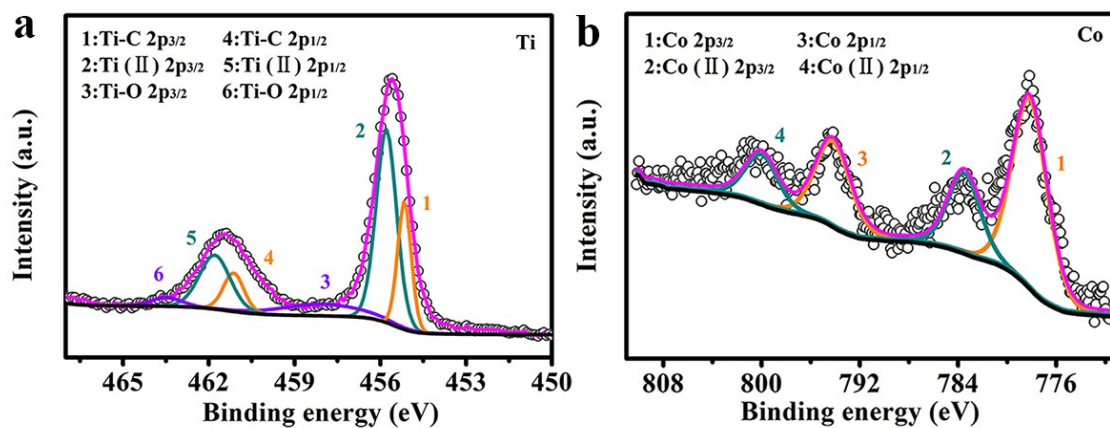


Figure S6 XPS spectrum of (a) Ti 2p and (b) Co 2p for MG-Co composite.

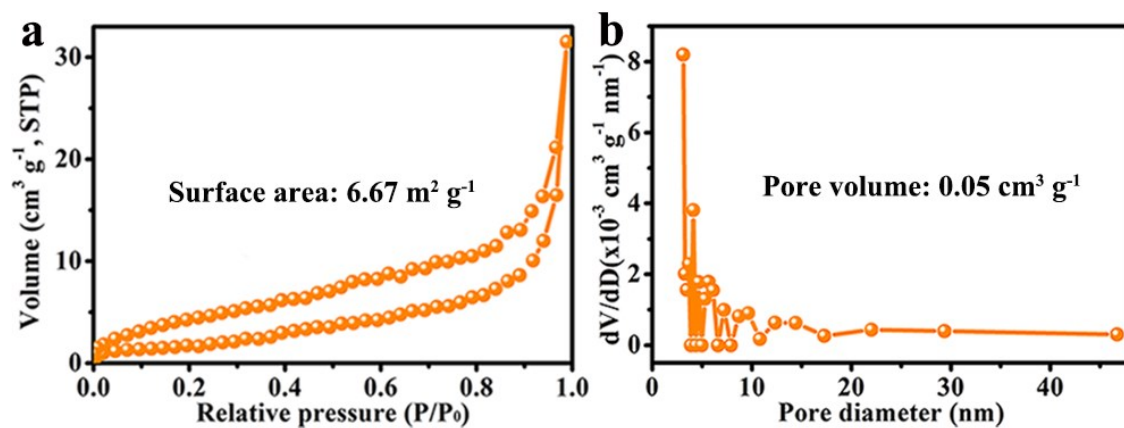


Figure S7 (a) N_2 adsorption and desorption curves and (b) pore size distribution curve

of MG-Co@S.

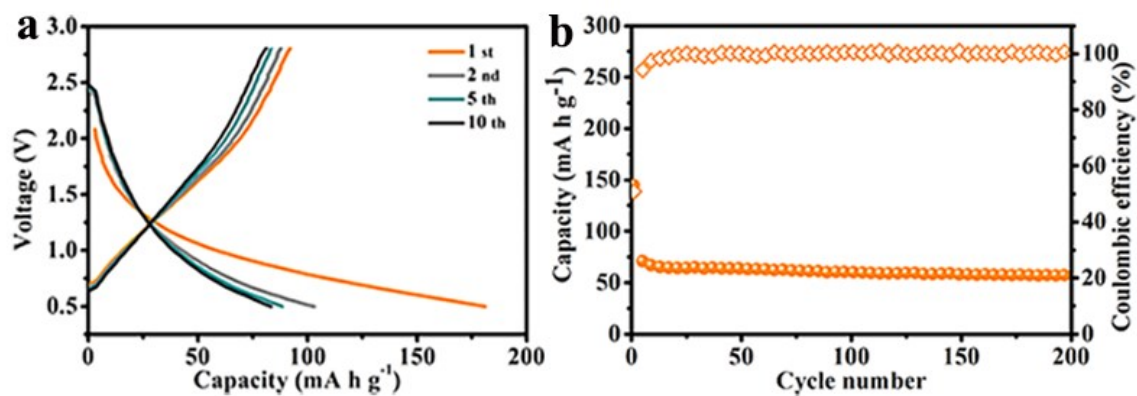


Figure S8 (a) charge/discharge profiles and (b) cycling performance of MG-Co at 0.5

C.

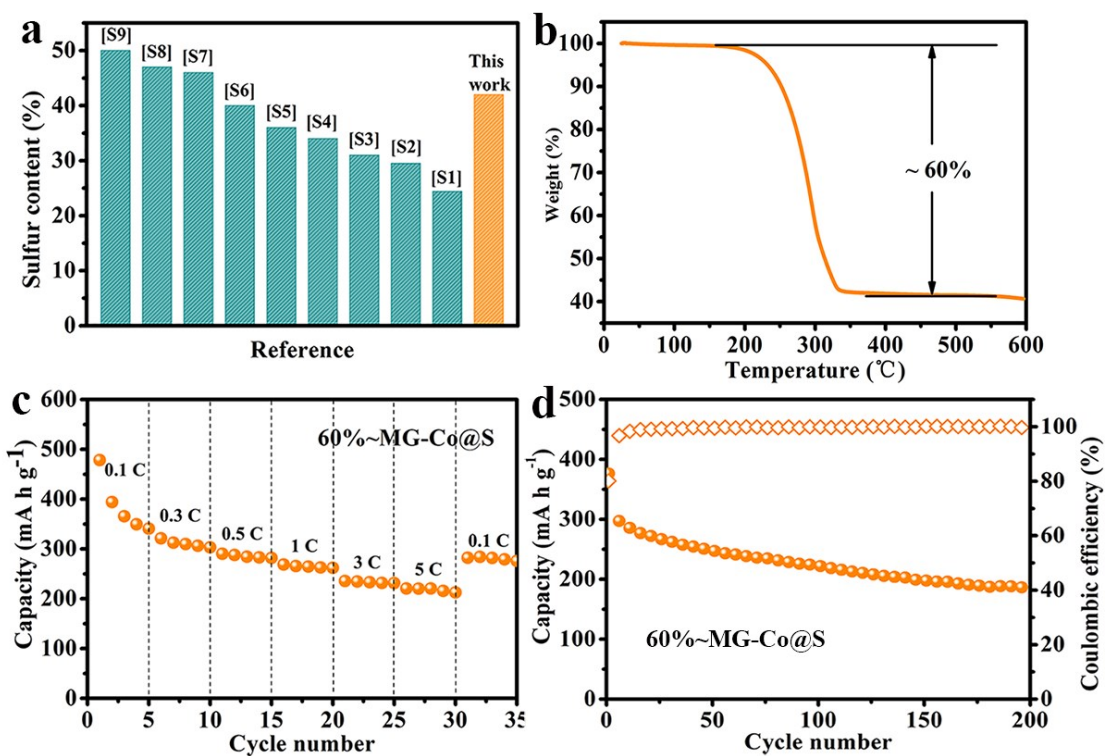


Figure S9 (a) Comparison the sulfur content of this work with other literatures (b) TGA curve, (c) rate capability and (d) cycling performance at 0.5 C of MG-Co@S with higher sulfur loading.

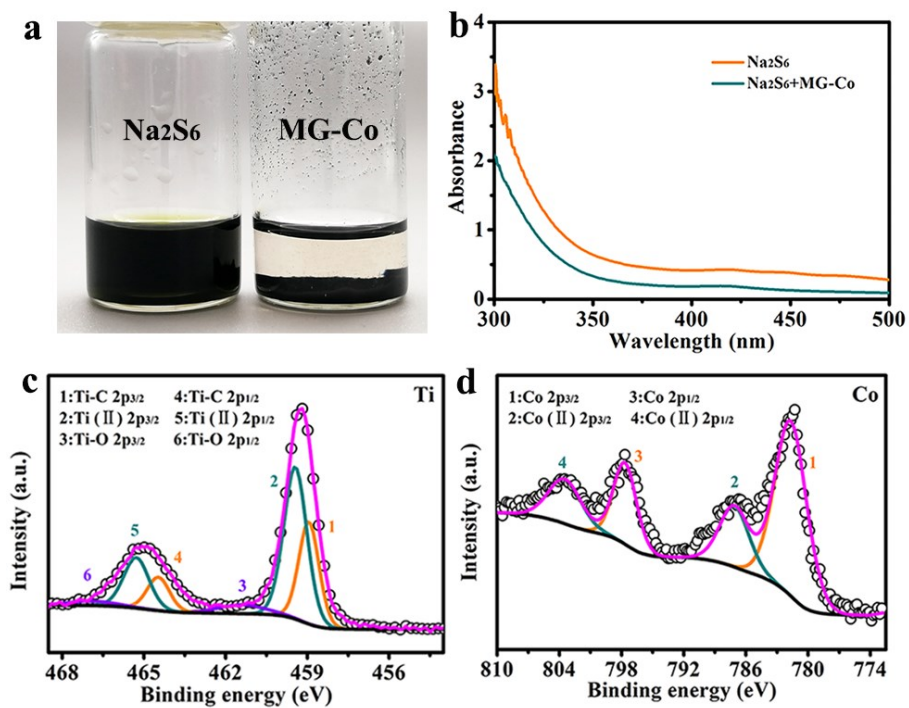


Figure S10 (a) Polysulfides adsorption by MG-Co, (b) UV-vis absorption spectra of Na₂S₆ solution before and after adding MG-Co, (c) the high-resolution XPS spectra of Ti 2p and Co 2p after adsorption of Na₂S₆.

Table S1 The comparisons of the performance between different cathode materials for RT Na-S batteries.

Materials	S (wt%)	Electrolyte	Rate	Cycles	Final capacity (mA h g ⁻¹)	Ref.
MG-Co@S	42	1.0 M NaPF6 in DOL:DIGLYME	0.5 C	200	360	This work
CFC/S	24.4	1.5 M NaClO ₄ and 0.2 M NaNO ₃ in TEGDME	0.1 C	300	120	S1
S Nanosheets @Cu foam	29.5	1.0 M NaClO ₄ in PC:EC+5% FEC	50 mA g ⁻¹	5	377	S2
cPANS	31	0.8 M NaClO ₄ in EC:DEC	220 mA g ⁻¹	500	150	S3
PCMs-S	34	1.0 M NaClO ₄ in PC:EC+5% FEC	100 mA g ⁻¹	350	300	S4
S@Ni-NCFs	36	1.0 M NaClO ₄ in TEGDME	0.5 C	270	233	S5

rGO/VO ₂ /S	40	1.0 M NaClO ₄ in TEGDME	2 C	1000	156	S6
S@iMCHS	46	1.0 M NaClO ₄ in PC:EC+5% FEC	100 mA g ⁻¹ 1	200	292	S7
S@Co _n -HC	47	1.0 M NaClO ₄ in PC:EC+5% FEC	100 mA g ⁻¹ 1	600	508	S8
cZIF-8/S	50	1.0 M NaClO ₄ in TEGDME	0.2 C	250	450	S9
HSMC-Cu-S	50	1.0 M NaClO ₄ in EC:DMC	0.03 C	110	610	S10
CNT@GNR/S	63	1.0 M NaClO ₄ in PC:EC	0.2 C	300	350	S11

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