Electronic Supplementary Information (ESI)

A Novel Rose-With-Thorn Ternary MoS_2@Carbon@Polyaniline Nanocomposite as Rechargeable Magnesium Battery Cathode Displaying Stable Capacity and Low-Temperature Performance

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EXPERIMENTAL SECTION

Synthesis of rose-like MoS_2

The rose-like MoS_2 was synthesized through a typical hydrothermal method. Typically, 1.24 g ammonium molybdate and 0.75 g thioacetamide were dissolved in 40 mL deionized water under stirring. The solution was stirred for 30 min, then transferred into a Teflon-lined stainless-steel autoclave, which was heated in an oven at 190 °C for 12 h. The samples were obtained by centrifugation, washed with deionized water and ethanol alternately four times, and dried at 60 °C.

Preparation of MoS_2@C@PANI composite

First, a layer of carbon was coated on the surface of MoS_2. 0.2 g MoS_2 was dispersed in 50 mL deionized water. After 1 min of ultrasonication, 1.121 g (hydroxymethyl) methyl aminomethane was added under stirring. The pH was adjusted to 8.5 by adding

8 drops of hydrochloric acid. Next, 0.075 g dopamine hydrochloride was put into the solution, which was stirred for 24 h. The sample was washed with deionized water and dried at 60 °C. It was annealed at 600 °C for 4 h in nitrogen atmosphere. After that, 0.1 g of the sample was added into 60 mL of 0.5 M H_2SO_4. Then, 0.455 mL aniline was added under stirring. 0.575 g ammonium persulfate was dissolved in 40 mL of 0.5 M H_2SO_4 drop by drop under stirring for 12 h in an ice bath. At last, the sample was collected and washed.

Characterization

The morphology and composition were investigated on a scanning electron microscopy (SEM, Hitachi S-8100, operated at 5 kV), a transmission electron microscopy (TEM, Hitachi HT7700), and a high-resolution TEM (HRTEM, Tecnai G2 20 S-TWIN, FEI). X-ray diffraction (Bruker D8 Advance) and X-ray photoelectron spectroscopy (XPS, ESCALAB 250) were used to measure phase and composition. The element mapping was performed on an energy dispersive X-ray spectrometer (EDS) analyzer. The composition was measured by thermogravimetric analysis (TGA, Setaram Labsys Evo SDT Q600). The Raman spectrum was measured on a spectroscopic method (Renishaw in Via). Fourier transform infrared spectroscopy (FTIR) was determined by G/FTIR-8400S (PerkinElmer).

Electrochemical tests

The electrochemical performance was evaluated through a coin-typed cell system. A

slurry was prepared by samples (80 wt%), carbon black (10 wt%) and polyvinylidene fluoride (10 wt%). The slurry was coated uniformly on carbon paper with a diameter of 14 mm and a thickness of 0.015 mm, dried in a vacuum oven at 60 °C for 12 h. The 0.4 M $(PhMgCl)_2$-$AlCl_3$/THF was used as electrolyte. Cells were assembled in a glove box (Mikrouna, Super 1220/750/900) filled with Ar gas. The AZ31 Mg alloy was used as reference electrode in our study, which was purchased with a high purity. The material loading and the electrolyte/sulfur ratio were about 1.45 mg cm^{-2} and 15 μL mg^{-1}. The charge-discharge and rate-performance were tested in a potential window of 0.01-2 V on Neware CT-3008. Cyclic voltammetry (CV) curves and electrochemical impedance spectroscopy (EIS) spectra were recorded on the same electrochemical workstation (CHI-660E).

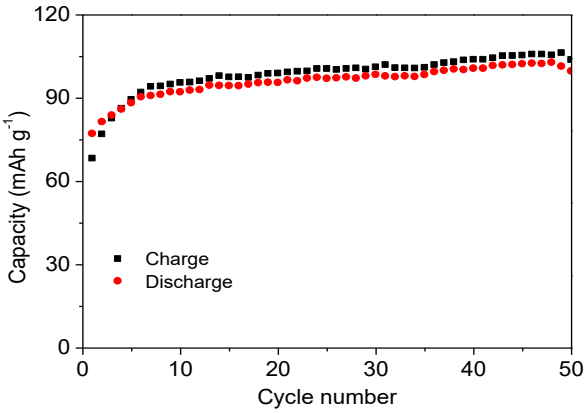

Fig. S1 Cycling performance of the MoS_2@C@PANI cathode at 0.1 A g^{-1} under –10 °C.

Table S1. Comparison on the performance of some nanocomposite-based cathodes.

Material	Preparation approach	Rate ($mA\ g^{-1}$)	Cycle number	Capacity ($mAh\ g^{-1}$)	Ref.
MnO_2/MXene-V_2C	Etching method	100	100	76.7	1
CuS	Self-doping strategy	1000	550	72.5	2
$MgFe_xMn_{2-x}O_4$	Spinel-type metal	1000	1000	88.3	3
Ni-doped magnesium manganese oxide	Hydrothermal method	100	100	107	4
$MgMn_{1.8}Sr_{0.2}O$	Self-propagating combustion method	100	10	59	5
SnO_2-rGO	Self-assembly reaction	100	150	102	6
MoS_2@C@PANI	Hydrothermal reaction	100	100	114	This study

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