Supporting Information

MoS_2 Modified with Citric Acid under Plasma Treatment for High-Performance Supercapacitor

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List of Texts and Figures

Text S1. Experimental section.

1.1 Chemicals: Ammonium molybdate tetrahydrate ($(NH_4)_6Mo_7O_{24}\cdot 4H_2O$, 99%), thioacetamide ($C_2H_5NS$, 99%), ethanol ($CH_3CH_2OH$, 95%), polyethylenepolypropylene glycol ($H(OCH_2CH_2)_x(OCH_2CHCH_3)_y(OCH_2CH_2)_zOH$, F68), anhydrous sodium sulfatewere (Na_2SO_4, 99%) and potassium chloride (KCl, 99.8%) were purchased from Sinopharm Chemical Reagent Co. Ltd. (Shanghai, China). All chemicals were used without any further purification.

1.2 Preparation of MoS_2/C-100 W, MoS_2/C-200 W, and MoS_2/C-300 W electrode

In the experiment, 0.7242 g of ammonium molybdate ($(NH_4)_6Mo_7O_{24}\cdot 4H_2O$), 1.4209 g of thioacetamide (CH_4N_2S) and 0.1 g citric acid ($C_6H_8O_7$, CA) were dissolved in a mixed solution containing 22 mL of deionized water. The mixed solution was stirred vigorously with a magnetic stirrer until it became transparent. It was then transferred to a Teflon-lined stainless steel autoclave and heated to 210 °C for 18 hours. After the reaction cooled to room temperature, the samples underwent thorough washing with deionized water and ethanol, conducted three to four times to achieve high purity. Deionized water effectively removes polar impurities, while ethanol aids in dissolving organic contaminants. Subsequently, the cleaned samples were dried in a vacuum oven at 60°C to prevent degradation or moisture retention.

The process of creating a composite electrode involves mixing activated carbon super-p and polyvinylidene fluoride (PVDF) in N-methylpyrrolidone (NMP) to obtain a homogeneous slurry. The combination leverages the high surface area of super-p for

enhanced electrochemical performance while utilizing PVDF as a binder to ensure structural integrity. The resulting slurry is then coated onto nickel foam (NF), which serves as a current collector due to its high conductivity and lightweight properties.

The Ni foam covered with MoS_2/C was treated by plasma activation with air, 60 Pa of pressure, and 5 min of activation time. The working electrodes made of MoS_2/C are subjected to varying power levels-100 W, 200 W, and 300 W. These treatments, referred to as MoS_2/C-100 W, MoS_2/C-200 W, and MoS_2/C-300 W, aim to optimize the electrochemical properties of the electrodes.

1.3 Electrochemical measurement and evaluations

Electrochemical performance is measured using a three-electrode configuration. The three-electrode configuration consists of a 1×1 cm^2 platinum plate as the counter electrode, Ag/AgCl in 1 M KCl as the reference electrode, and the tested electrode as the working electrode. The electrochemical data is obtained using the Dutch Ivium (Vertex. C. DC) electrochemical station in 1 M Na_2SO_4, allowing for the collection of cyclic voltammetry (CV), galvanostatic charge-discharge (GCD), and electrochemical impedance spectroscopy (EIS).

1.4 Preparation of symmetric supercapacitor (SSC) device

Initially, 1 g of polyvinyl alcohol (PVA) powder was dissolved in 10 mL of deionized (DI) water, and the mixture was heated to 90°C with meticulous stirring until the solution turned clear. Subsequently, 3-5 mL of aqueous Na_2SO_4 (1 M) was added by drop into the above solution while continuously stirring. MoS_2/C-200 W on carbon cloths were assembled. After the PVA-Na_2SO_4 gel solidified at room temperature, the

symmetric supercapacitor (SSC) device was achieved.

Text S2. Material characterizations

XRD spectra were collected on X-ray diffraction (PANalytical Empyrean) with Cu Kα radiation (λ = 0.154 nm). Materials nanostructure characterizations come from Field emission scanning electron microscope (FE-SEM, HiTACHI Regulus8220) and Energy-dispersive X-ray spectroscopy (EDX, Oxford EDX, with INCA software), and transmission electron microscope (TEM, JEM-2100) with configured EDX. Valence structure was collected by X-ray photoelectron spectroscopy (XPS, Thermo ESCALAB 250Xi equipped with monochromatic Al Kα source).

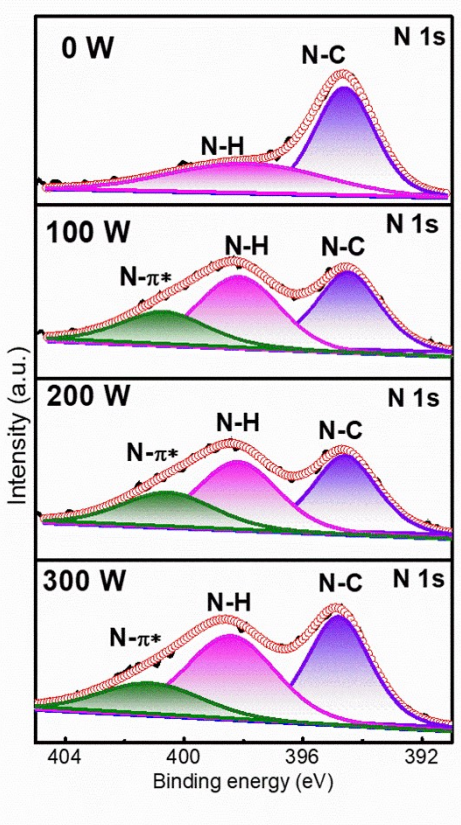

Fig. S1. The high-resolution XPS of N 1s for MoS_2/C, MoS_2/C-100W, MoS_2/C-200W, and MoS_2/C-300W.

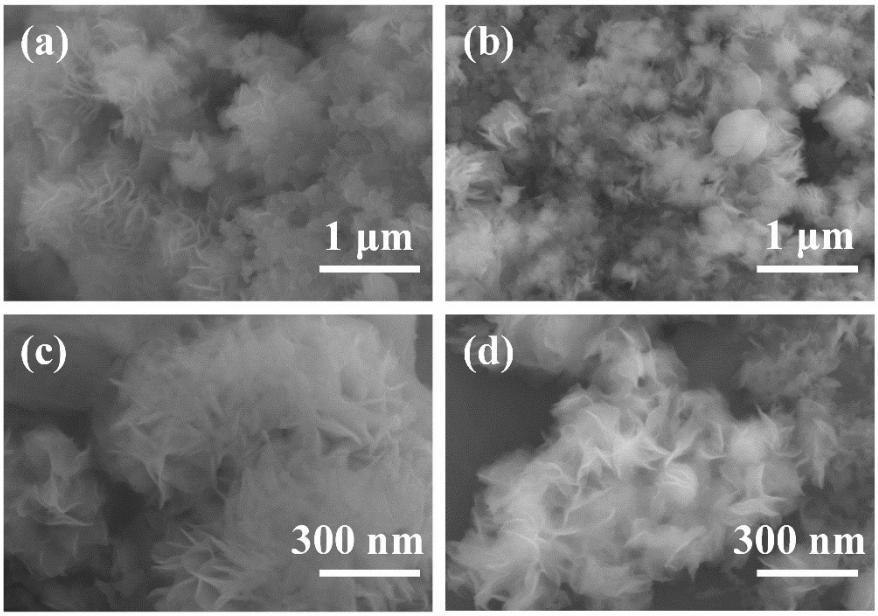

Fig. S2. SEM images of MoS_2/C, MoS_2/C-100 W, MoS_2/C-200 W, and MoS_2/C-300 W.

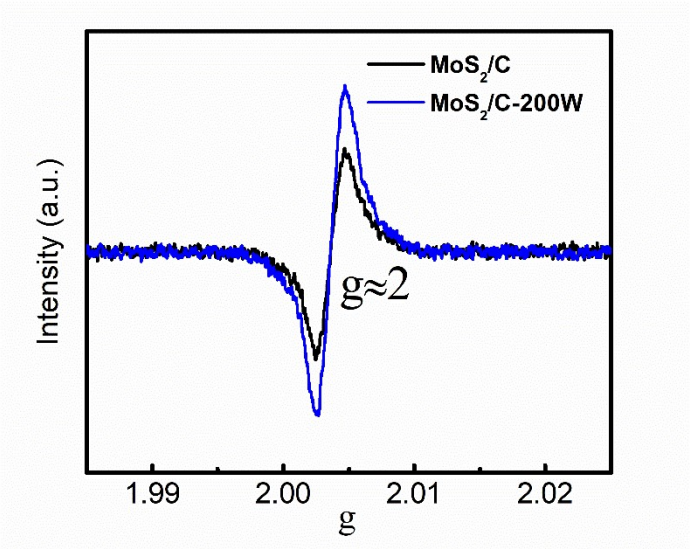

Fig. S3. EPR spectra of MoS_2/C and MoS_2/C-200W at room temperature.

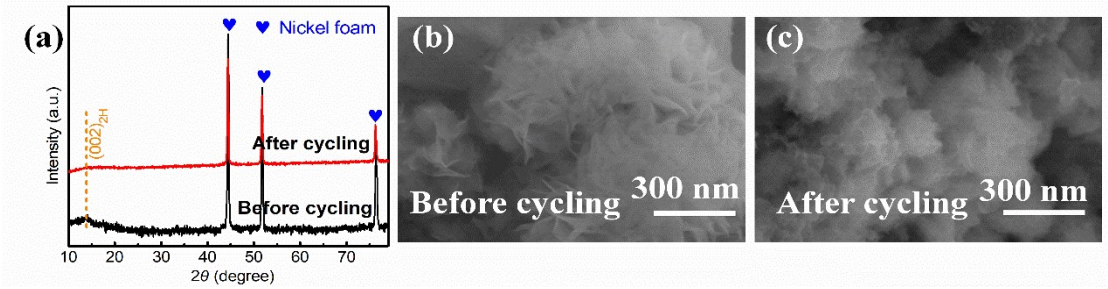

Fig. S4. The XRD patterns and SEM images of MoS_2/C-200 W before and after cycling.

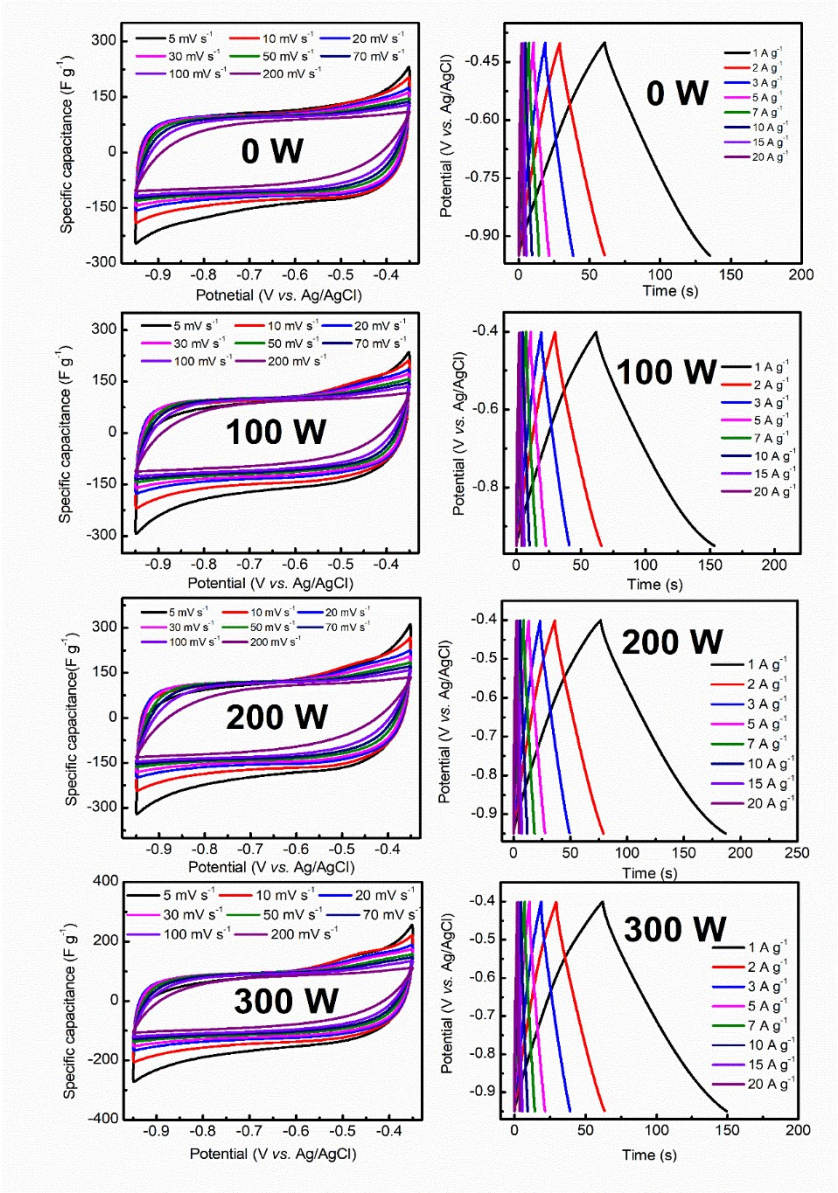

Fig. S5. The CV and GCD curves of MoS_2/C, MoS_2/C-100 W, MoS_2/C-200 W, and MoS_2/C-300 W at a series of scan rates and current densities.

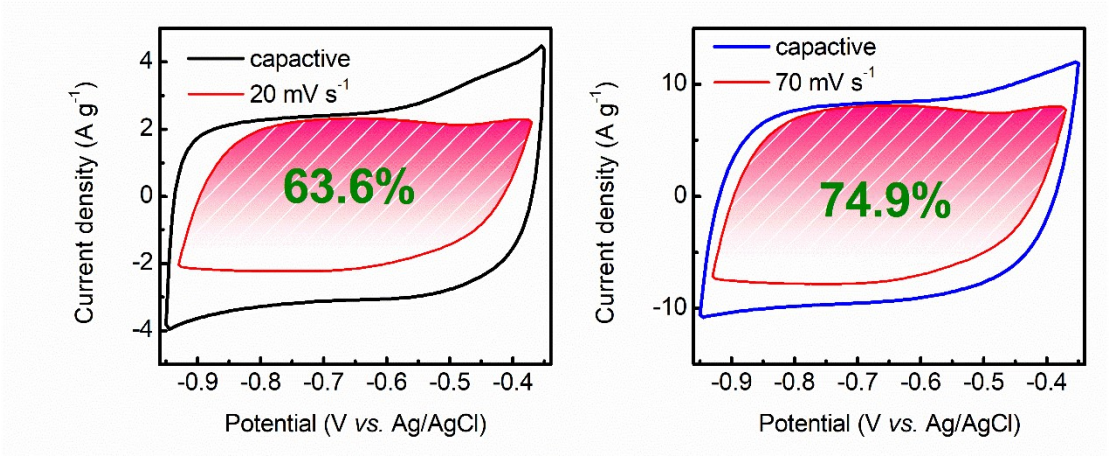

Fig. S6. CV partition analysis showing the capacitive contribution to the total current for MoS_2/C-200 W electrode at 20 and 70 mV s^{-1}.

Table S1. The specific capacitance, power density and energy density of SSC device.

Current density (mA cm^{-2})	**1**	**2**	**3**	**5**	**7**	**10**	**15**	**20**
Specific capacitance (mF cm^{-2})	202	172	159	140	129	118	101	87
Power density (μWh cm^{-2})	275.85	549.11	829.24	1374.55	1931.88	2747.08	4125.41	5728.7
Energy density (μW cm^{-2})	8.49	7.23	6.68	5.88	5.42	4.96	4.24	3.66