Journal Name

COMMUNICATION

Supporting Information

One-step synthesis of porous V_2O_3@C hollow spheres as a high-performance anode for lithium-ion batteries

Jianbiao Wang,[a, b] Zhenwei Liu,[a, b] Wenjuan Yang,[a, b] Lijin Han,[a, b] Mingdeng Wei [a, b*]

[a] State Key Laboratory of Photocatalysis on Energy and Environment, Fuzhou University, Fuzhou, Fujian 350002, China
[b] Institute of Advanced Energy Materials, Fuzhou University, Fuzhou, Fujian 350002, China

*Corresponding author: Mingdeng Wei
E-mail address: wei-mingdeng@fzu.edu.cn

Experimental Section

Preparation of porous V_2O_3@C hollow sphere

In a typical process, 0.3 g vanadium acetylacetonate and 0.1 g glucose were added 35 ml isopropanol under stirring for 60 minutes. Then, the mixed solution was transferred into 50 ml Teflon autoclave, and subsequently heated at 200 °C for 24 h. It was collected with centrifugation and washed with deionized water and ethanol several times, when it cooled naturally to room temperature. Finally, the obtained product was dried at 70 °C oven for overnight.

Material Characterization

X-ray diffraction spectrometry (XRD), were recorded on a Rigaku Ultima IV with Cu Ka radiation (1.5418 A) to characterize the crystal phase properties of the samples. Raman spectrum was obtained on a HR Evolution Raman system using a 532 nm excitation source at room temperature. The morphology and interior structure of the as-prepared sample were collected by scanning electron microscopy (SEM, Hitachi S4800 instrument) and transmission electron microscopy (TEM, FEI F20 STWIN instrument). X-ray photoelectron spectroscopy (XPS) was implemented on a Thermo Scientific ESCALAB 250 instrument to analyze the chemical and oxidation states of V, O and C in the hybrid material within the region of 0-1300 eV. N_2 adsorption-desorption analysis was carried out on a Micromeritics ASAP 2020 instrument to collect pore volumes and pore size distributions. Thermogravimetric analysis (TGA) was performed using a CHNS/O analyzer (PE 2400II, PerkinElmer, America) under air atmosphere to determine the actual amount of carbon in the obtained sample.

Electrochemical Measurements

The working electrodes were prepared by mixing active material, carbon black and polyvinylidene fluoride (PVDF) in a weight ratio of 80:10:10 and subsequently diluted with a certain of N-methylpyrrolidone (NMP) to achieve homogeneous slurry. And then, the slurry was casted on copper foil and transferred to vacuum oven dried at 110 °C overnight. CR2025-type coin cells were assembled in a glove box with an atmosphere of pure argon for electrochemical characterization. Lithium foil was regarded as the counter and reference electrodes and a microporous polypropylene membrane (Celgard 2400) as the separator. Besides, the electrolyte was 1 M $LiPF_6$ in a mixture of ethylene carbonate (EC), ethyl methyl carbonate (EMC) and dimethyl carbonate (DMC) with a volume ratio of 1:1:1. Galvanostatic charge-discharge curves and cycling performance were collected on the electrochemical workstation (Land CT 2001A, Wuhan, China) within the voltage region between 0.01 and 3.0 V (vs.Li^+/Li). Electrochemical impedance spectra (EIS) were recorded on an IM6 electrochemical workstation (Zahner Elektrik, Germany). Cyclic voltammograms (CV) were conducted on an electrochemical workstation (Chenhua CHI660c, Shanghai, China) at a sweep rate of 0.2 mV s^{-1} in a voltage range from 0.01 to 3 V.

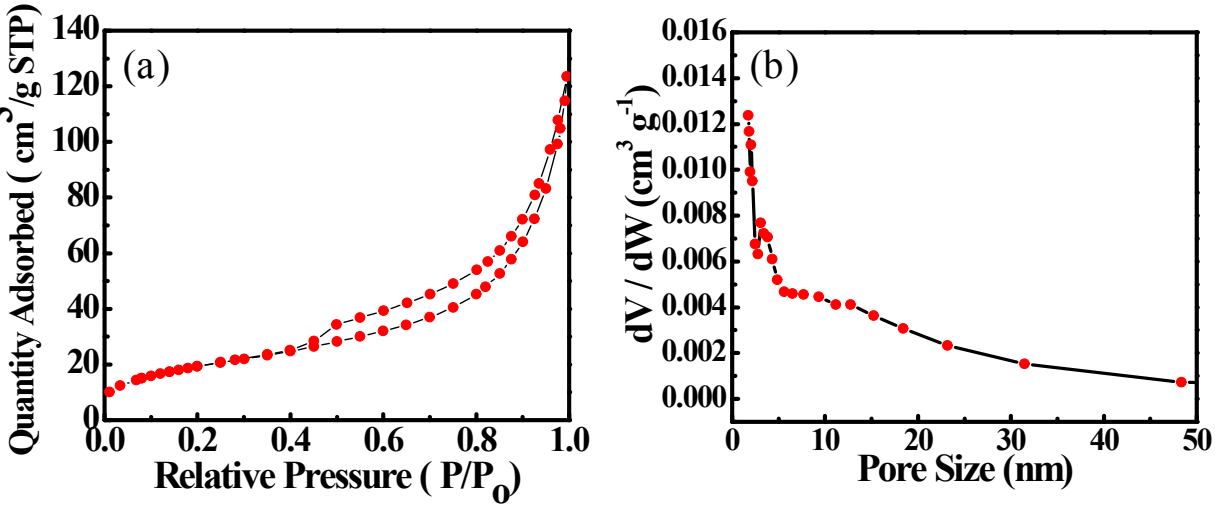

Fig. S1 (a) N_2 adsorption/desorption isotherms and (b) pore size distributions of V_2O_3@C hollow sphere.

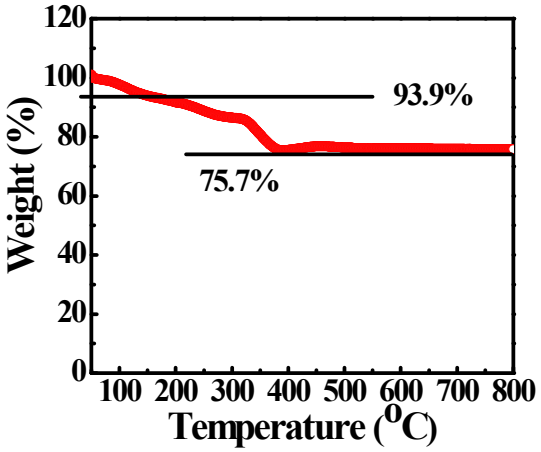

Fig. S2 TG curve of V_2O_3@C hollow sphere calcined in air.

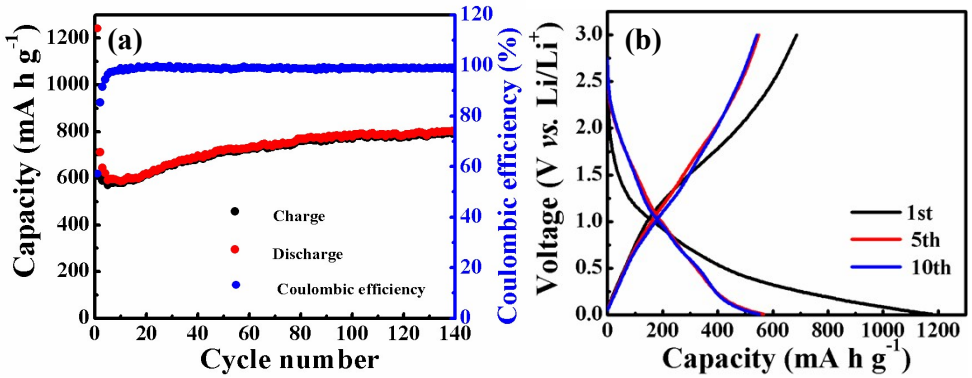

Fig. S3 (a) Cycling performance of V_2O_3@C hollow sphere at a current density of 0.2 A g^{-1} and (b) charge-discharge profiles of V_2O_3@C hollow sphere at 0.5 A g^{-1}.

Table S1 Comparison of the electrochemical properties of V_2O_3-based anode materials for LIBs

Electrode material	Voltage range (V)	Current density (mA g^{-1})	Cycle number	Capacity (mA h g^{-1})	Reference
V_2O_3-order mesoporous carbon	0.02-3	100	180	536	16
Vanadium oxide microspheres	0.01-3	2000	7000	328	32
		200	600	505	
Yolk-Shell V_2O_3 microspheres	0.01-3	100	100	437.5	25
Peapod-like V_2O_3 nanorods	0-3	100	125	210	26
Reduced graphene oxide modified V_2O_3	0.01-3	100	50	380	27
		500	250	270	
V_2O_3 anchored onto reduced graphene	0-3	1860	1000	350	18
Porous and intercalation type V_2O_3	0.01-3	100	136	732	22
		1000	160	424	
V_2O_3@C hollow spheres	**0.01-3**	**500**	**250**	**720**	**This work**
		2000	**800**	**583**	

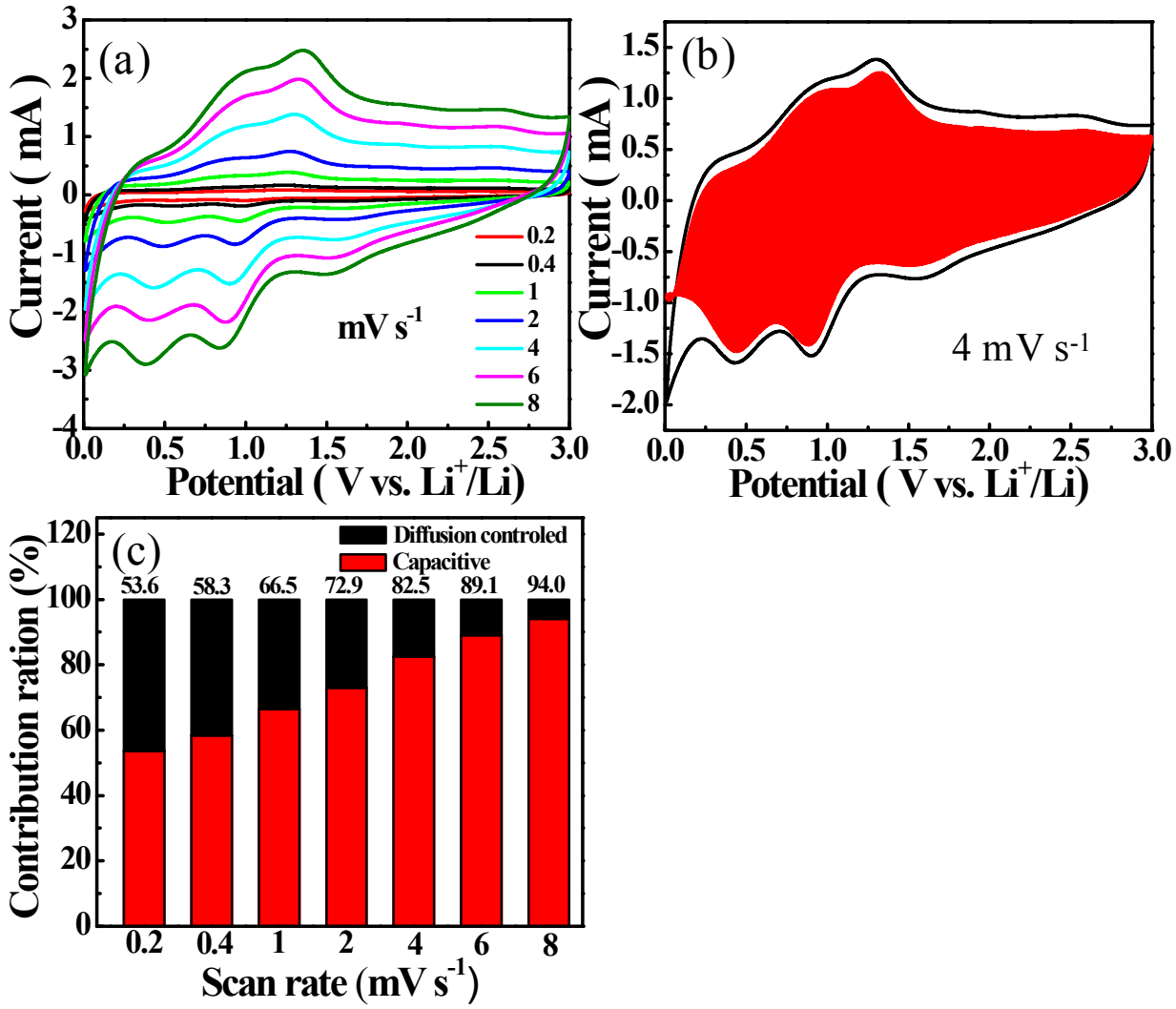

Fig. S4 (a) CV curves at various scan rates from 0.2 to 8 mV s^{-1} , (b) separation of the capacitive and diffusion currents at a scan rate of 4 mV s^{-1}, and (c) contribution ratio of the capacitive and diffusion-controlled charge at various scan rates, respectively.

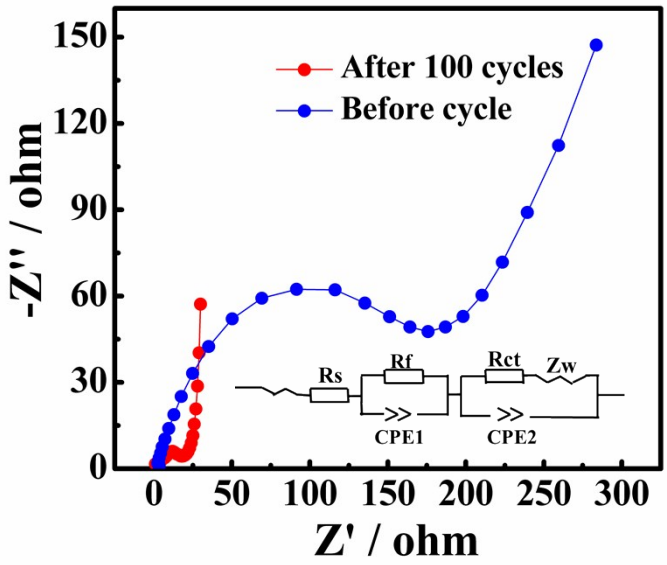

Fig. S5 Electrochemical impedance plots of V_2O_3@C hollow sphere before cycling and after 100 cycles. (Inset: Equivalent circuit mode corresponding to Nyquist plots)

Table S2 Impedance parameters of V_2O_3@C hollow sphere obtained from equivalent circuit model

	Rs	**Rf**	**Rct**
before cycle	1.7		150
after 100 cycles	1.9	10.8	10.5