

## ELECTRONIC SUPPORTING INFORMATION

---

### Supporting information

The graphene-like hollow sphere anode for lithium-ion battery

Lili You <sup>a</sup>, Shu Dong <sup>a\*</sup>, Yongzheng Fang <sup>c</sup>, Yan Guo <sup>a</sup>, Kai Zhu <sup>a</sup>, Yinyi Gao <sup>a</sup>,  
Tianzeng Bao <sup>a</sup>, Hongbin Wu <sup>b</sup>, and Dianxue Cao <sup>a\*</sup>

<sup>a</sup> *Key Laboratory of Superlight Materials and Surface Technology (Ministry of Education),  
College of Material Science and Chemical Engineering, Harbin Engineering University,  
Harbin, China, 150001.*

<sup>b</sup> *Hunan Hongshan New Energy Technology Co., Ltd, Henglongqiao Town, Heshan District,  
Yiyang City, Hunan Province, 413000 (P. R. China)*

<sup>c</sup> *School of Chemical Engineering, Zhengzhou University, Zhengzhou 450001, Henan, China.*



# ELECTRONIC SUPPORTING INFORMATION

---

## Content

<b>1. Experimental</b> .....	1
1.1 Preparation of pre-carbonized hollow mesoporous carbon spheres .....	1
1.2 Preparation of L-GHS by flash joule heating method .....	1
1.3 Electrochemical measurement .....	1
1.4 Characterization .....	2
<b>2. Supporting Figures</b> .....	2
<b>3. Supporting tables</b> .....	4

## 1. Experimental

### 1.1 Preparation of pre-carbonized hollow mesoporous carbon spheres

First, 1.7 mL of TEOS was mixed well with 30 mL of ethanol. Then 20 mL of ethanol, 6 mL of deionized water, and 4 mL of ammonia (28 wt%) was added to the solution, and stirred for 1 h. After stirring uniformly, resorcinol and formaldehyde solution (37 wt%) were added and stirred at 30 °C for 24 h. The solution was transferred to a 100 mL reaction kettle and hydrothermally treated at a temperature of 100 °C for 24 h. After cooling, it was centrifuged and dried to obtain the SiO<sub>2</sub>@RF material. SiO<sub>2</sub>@RF was pre-carbonized in a tube furnace under argon protection at 800 °C for 15 min to obtain the SiO<sub>2</sub>@C. Subsequently, SiO<sub>2</sub>@C was established in 100 mL of HF solution (10%) stirred for 24 h to wash away the SiO<sub>2</sub>. After centrifuging and drying the pre-carbonized hollow mesoporous carbon spheres RF-800 was obtained. To investigate the optimal composite ratio of silica to a carbon source, resorcinol and formaldehyde were added in the amounts of 0.2 g, 0.28 mL; 0.4 g, 0.56 mL; and 0.8 g, 1.12 mL, respectively. And the samples were named as SiO<sub>2</sub>@C-1, SiO<sub>2</sub>@C-2, and SiO<sub>2</sub>@C-3, respectively.

### 1.2 Preparation of L-GHS by flash joule heating method

After pre-carbonization, 30 mg of hollow mesoporous carbon spheres were loaded into a quartz tube with a diameter of 4 mm and a wall thickness of 2 mm. And 4 mm graphite rods were filled in both ends. After compacting, the quartz tube was put into a Joule-heated transient electric shock device which is connected with a series of independently-controlled capacitors of 5.6 mF by graphite rods contact media to investigate the effects on L-GHS under different electric shock conditions. The equipment parameters use one capacitor under the condition of 200 V voltage. The materials electrocuted 1, 2, and 3 times were named RF 1-200-1, RF 1-200-2, and RF 1-200-3, respectively (Each shock lasts no more than 3s).

### 1.3 Electrochemical measurement

The anode electrode slurry was prepared by mixing the sample (L-GHS), the conductive agent (super-p), and the binder (PVDF) in a ratio of 80:10:10 and uniformly coated on the copper foil. Subsequently, they were vacuum dried at 60 °C for 12 h and then cut into 12 mm round

## **ELECTRONIC SUPPORTING INFORMATION**

---

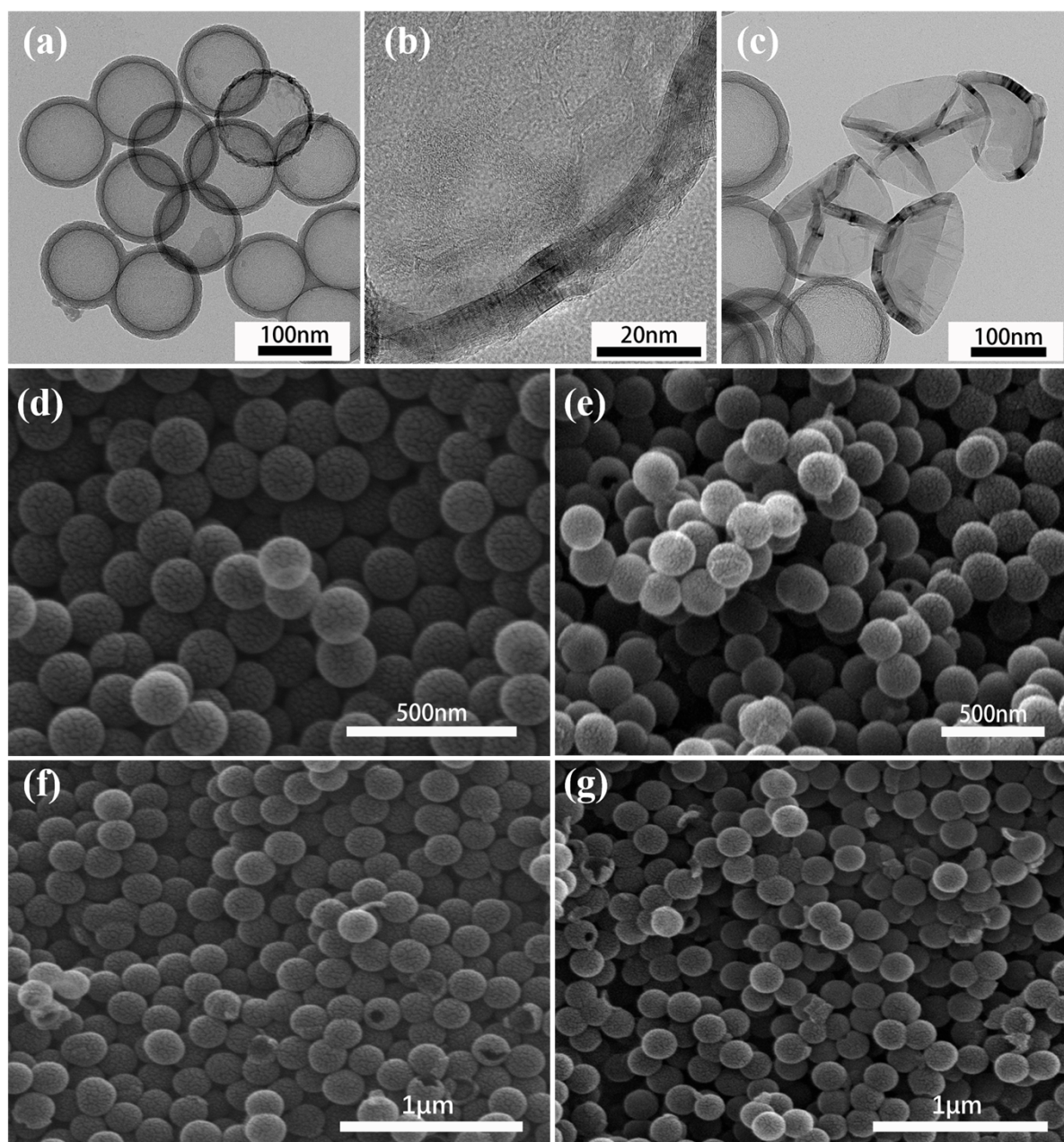
electrode pole pieces. Electrochemical testing was performed on a battery test system (NEWARE BTS-5 V 20 mA; NEWARE Technology Co., Ltd.) with a voltage range of 0.01 to 3 V.

### **1.4 Characterization**

The material structure was characterized by X-ray diffraction (XRD, TTR III; Rigaku) using a Cu-targeted  $K\alpha$ -ray source in the range of 10-80° with a sweep rate of 10°/min. A transmission electron microscope (TEM, Fei Tecnica G2-STWIN; Philips) with an accelerating voltage of 200 kV was used to characterize the material morphology. A scanning electron microscope (SEM, JSM-6480; JEOL) with a resolution of 3 nm and an operating voltage of 5-40 kV was used to characterize the surface morphology of the materials. The specific surface area and pore size of the materials were analyzed by Brunner-Emmet-Teller measurements (BET, NOVA 2000e; Quantachrome), using the principle that N<sub>2</sub> flows over the surface of the sample at low temperatures and is adsorbed to form an adsorption curve. The analysis of the degree of defects and graphitization of carbon materials was completed by Raman spectroscopy (Raman, HR-800; HORIBA Jobin Yvon) in the range of 50-4000 cm<sup>-1</sup>.

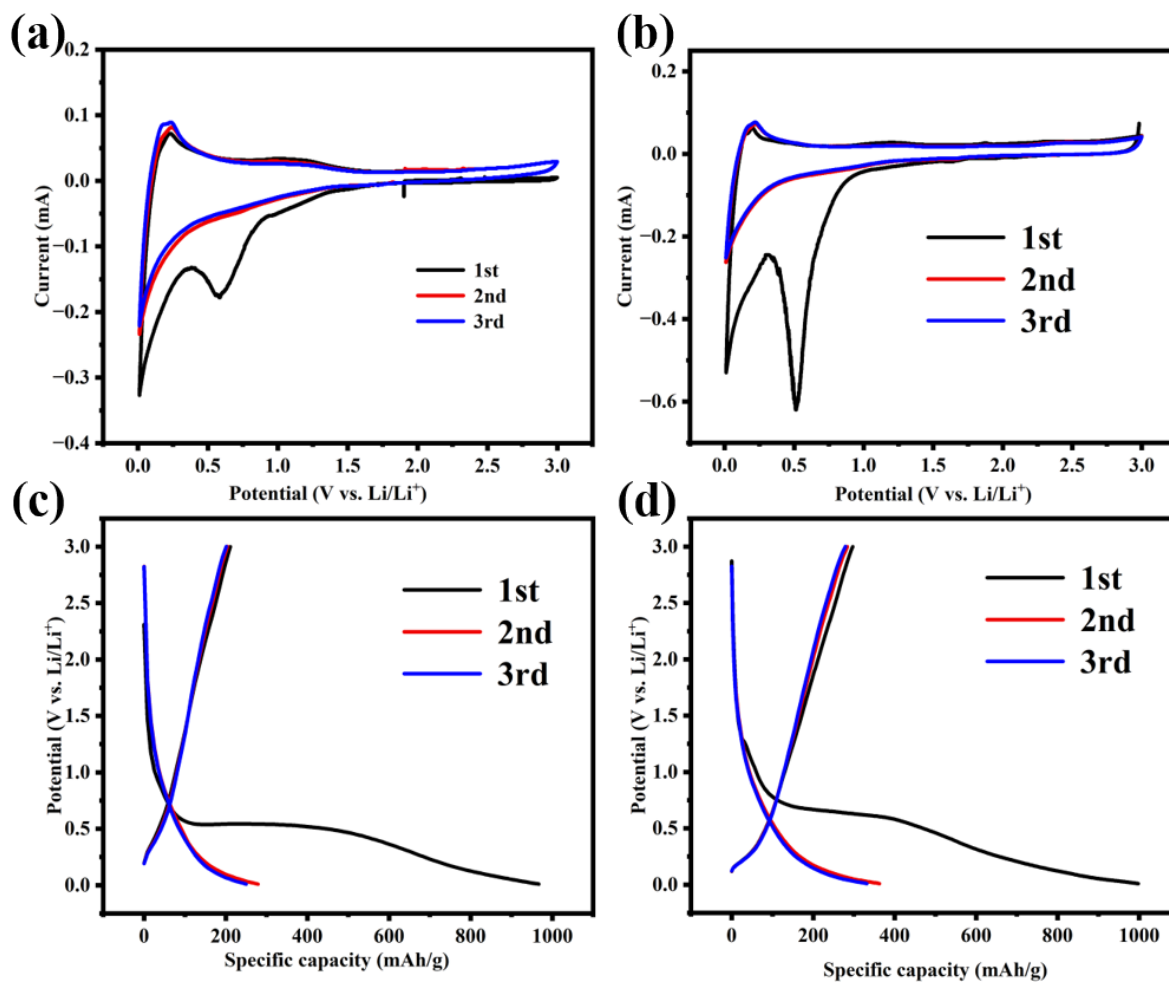
## **2. Supporting Figures**

## ELECTRONIC SUPPORTING INFORMATION

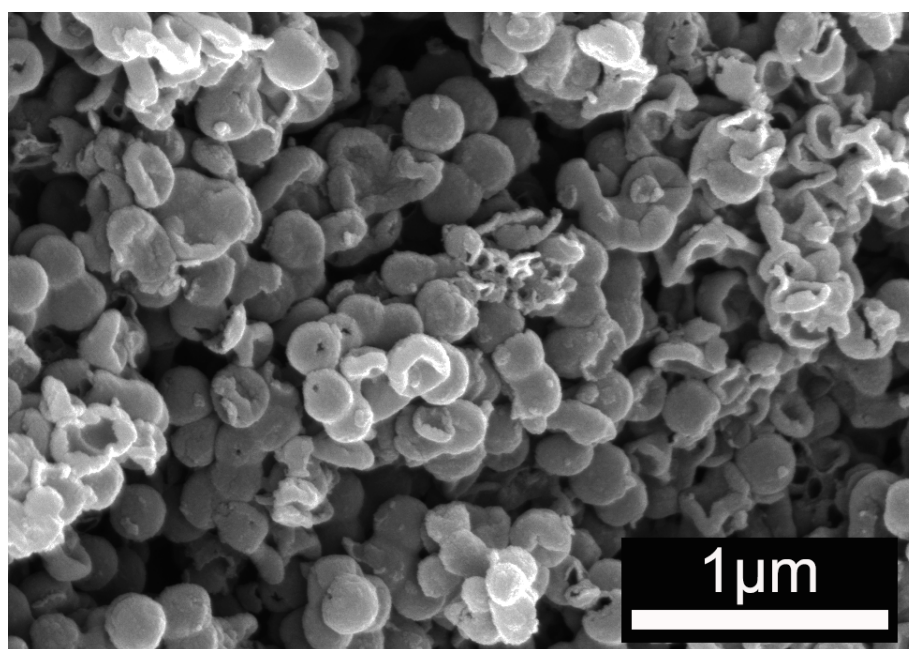


**Fig. S1.** (a) TEM and (b) HRTEM image of RF 1-200-1. (c) TEM image of RF 1-200-3. SEM images of (d) RF-800, (e) RF 1-200-1, (f) RF 1-200-2, (g) RF 1-200-3.

## ELECTRONIC SUPPORTING INFORMATION



**Fig. S2.** (a), (c): The cyclic voltammetry curves and the first three cyclic charge/discharge curves at a current density of 1 A/g of RF 1-200-1, and (b), (d) same test as above of RF 1-200-3.



**Fig. S3.** SEM image of RF 1-200-2 after 600 cycles

## ELECTRONIC SUPPORTING INFORMATION

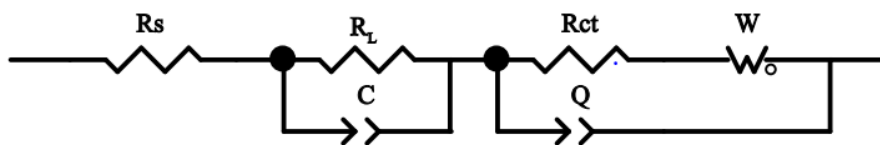


Fig. S4. The equivalent circuit model

### 3. Supporting tables

**Table S1** Specific surface area, pore volume, and mesopore interval distribution of RF-800 and RF 1-200-2.

	RF-800	RF 1-200-2
BET ( $\text{m}^2/\text{g}$ )	823	670
BJH ( $\text{cm}^3/\text{g}$ )	3.592	2.523
Major pore size distribution (nm)	25-40	35-70

**Table S2** Alternating current impedance data of RF 800-2h, RF 1-200-1, RF 1-200-2, RF 1-200-3

	$R_s$ ( $\Omega$ )	$R_{ct}$ ( $\Omega$ )	$R_L$ ( $\Omega$ )
RF 800-2h	2.68	241.7	231.7
RF 1-200-1	1.64	72.65	67.01
RF 1-200-2	1.34	61.3	59.32
RF 1-200-3	2.13	130	121.8