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Bio-inspired synthesis of carbon hollow microspheres from *Aspergillus flavus* conidia for lithium-ion batteries

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Experimental Section

Materials

Aspergillus flavus GZ-6 was kindly provided by Institute of Agro-Products Processing Science and Technology, Chinese Academy of Agricultural Sciences. Potato Dextrose Agar (PDA) was purchased from Hope Biol-Technology (Qingdao, China). Deionized water (resistance over 18 MΩ) was generated by a Millipore Q water purification system.

Preparation of *A. flavus* conidia-derived carbon microspheres

A. flavus (GZ-6) was cultured in a solid PDA medium (46 g L⁻¹) at 30 °C for 5~7 days. The fungus spores were collected from the culture dishes and washed with DI water. For the biosafety issue, the harvested conidia were autoclaved at 121 °C for 20 min. After that, the materials were immersed in a 4% glutaraldehyde solution for at least 4 h. Different concentrations of ethanol (10%, 30%, 50%, 70%, 90% and 100%) were

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used to dehydrate the conidia gradually. Finally, *A. flavus* conidia were dried at room temperature and calcined at 900 °C for 2 h under argon atmosphere.

Characterization of *A. flavus* conidia carbon materials

Optical micrographs of the *A. flavus* conidia were obtained using Inverted fluorescence microscope (Olympus IX71, Japan). SEM images were captured using a JSM-6510LV scanning electron microscope (JEOL, Tokyo, Japan) and field-emission scanning electron microscopy (JSM-7600, JEOL, Tokyo, Japan). EDS (INCA X-Max 250) spectra were collected to analyze the chemical elements of the samples. TEM image was collected using a JEM-2100 transmission electron microscope (JEOL, Tokyo, Japan) operating at 200 kV. XRD patterns were examined using a Cu *K* α -ray with tube conditions of 40 kV and 30 mA ranging from 10 to 80° (X-ray diffraction 7000, Shimadzu, Japan). The specific surface area was calculated by Brunauer-Emmett-Teller (BET) method using Quadrasorb evo 2QDS-MP-30 (Quantachrome Instruments, USA). The *A. flavus* conidia materials were further measured by Fourier Transform infrared spectroscopy (Nicolet 6700 FTIR, Thermo Electronic Corporation, USA) and Raman microscope using 532 nm laser excitation (Renishaw inVia Raman microscope, UK).

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Application of *A. flavus* conidia-derived carbon materials as anode materials for Lithium-ion batteries

Electrochemical measurements were performed using CR2032 coin cells assembled in an Ar-filled glovebox with lithium metal as the counter and reference electrodes. The work electrodes were prepared by mixing the active materials (80 wt%), super-P (10 wt%), and poly (vinyl difluoride) (PVDF, 10 wt%) pasting on a pure Cu foil. Celgard polypropylene membrane was used as a separator. The liquid electrolyte was 1 M LiPF₆ dissolved in EC/DEC (1:1 V/V). Charge and discharge measurements were carried out using a Land CT2001A battery test system (Wuhan LAND electronics Co., Ltd, China). Cyclic voltammetry (CV) were performed on CHI 760D electrochemical station (Shanghai Chenhua, China) with a scan rate of 0.5 mV s⁻¹. All electrochemical investigations were performed at room temperature (25 °C).

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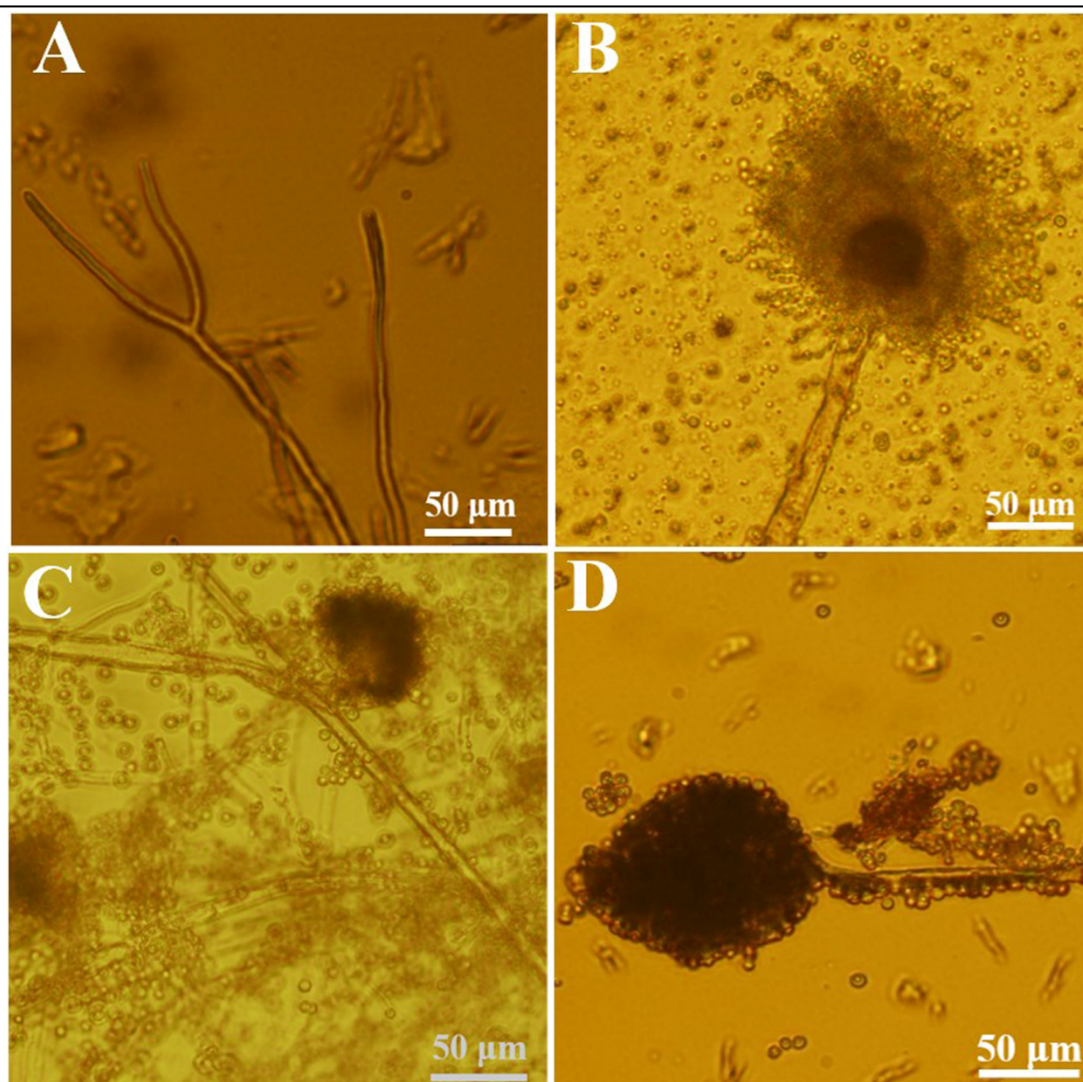


Figure S1. Optical micrographs of *Aspergillus flavus* on (A) 1st day, (B) 3rd day, (C) 5th day and (D) 7th day.

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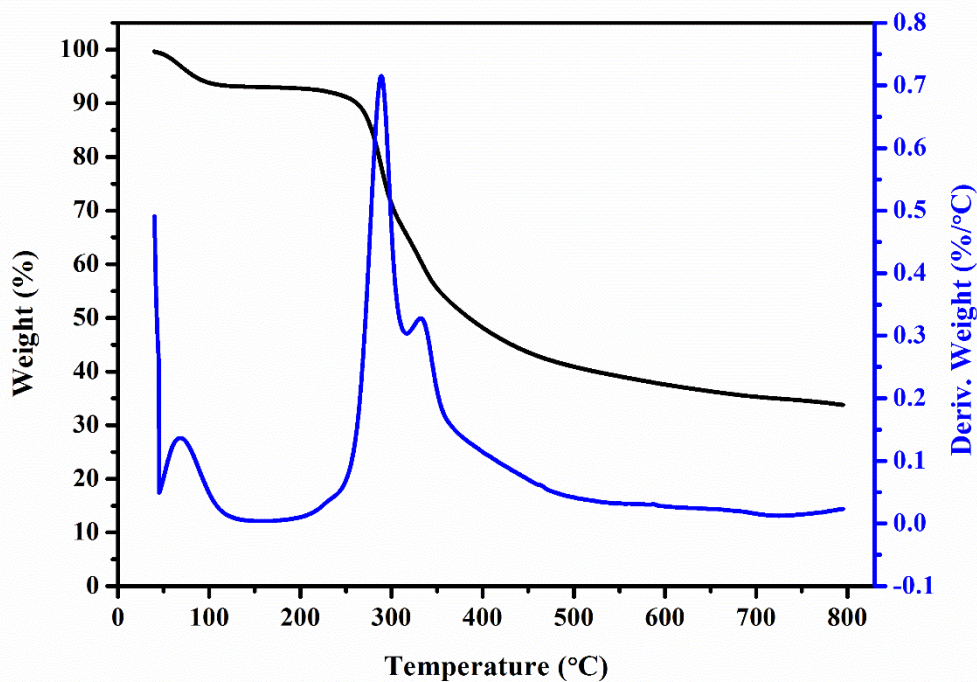


Figure S2. TGA and DTA of *A. flavus* conidia from 40 °C to 800 °C under N₂ atmosphere.

The weight loss before 250 °C could be attributed to H₂O evaporation. With the increasing the temperature to 450 °C, an obvious weight loss appeared, which due to carbonaceous pyrolysis process. The rate of weight loss became very slow and no peak can be seen from the DTA curve in temperature range of 450-800 °C. At 800 °C, weight loss was 66.3 wt %, namely, the char yield was 33.7 wt %.

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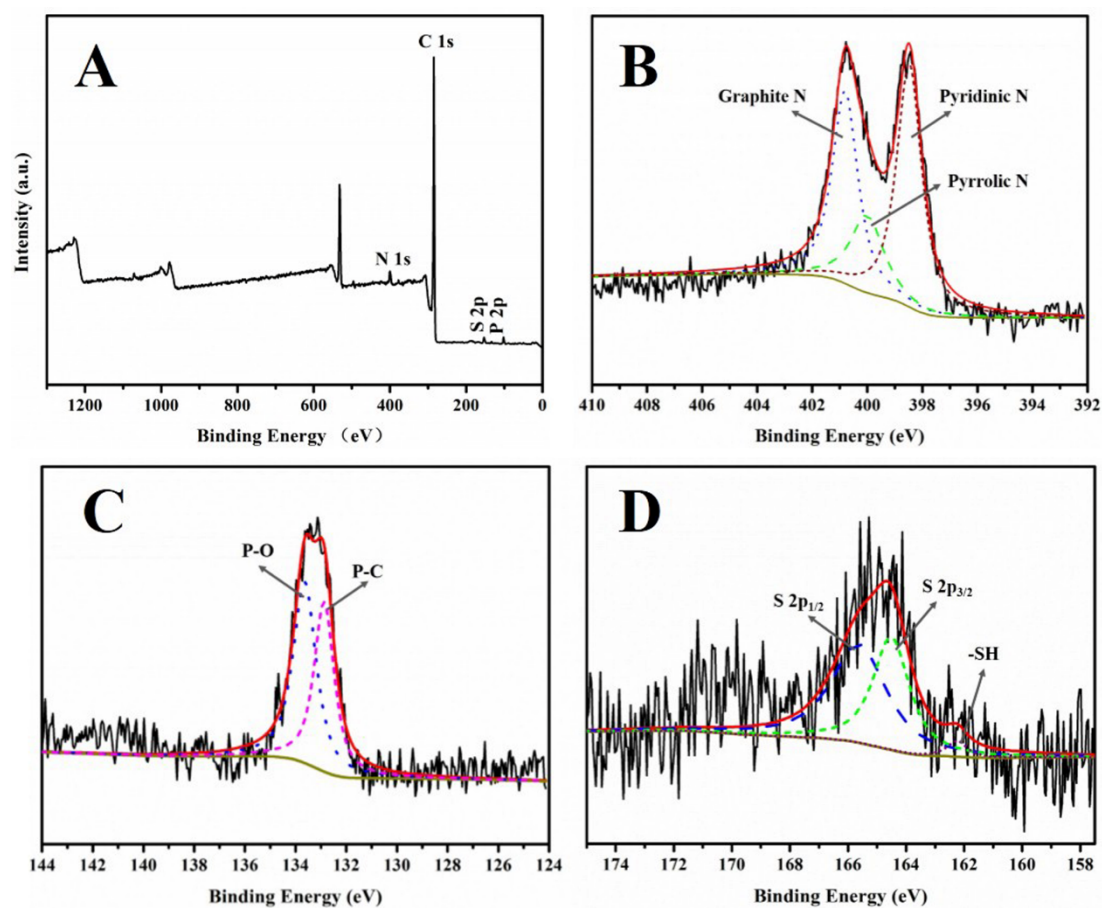


Figure S3. XPS spectra of conidia after calcination: (A) survey, (B) N 1s, (C) P 2p and (D) S 2p

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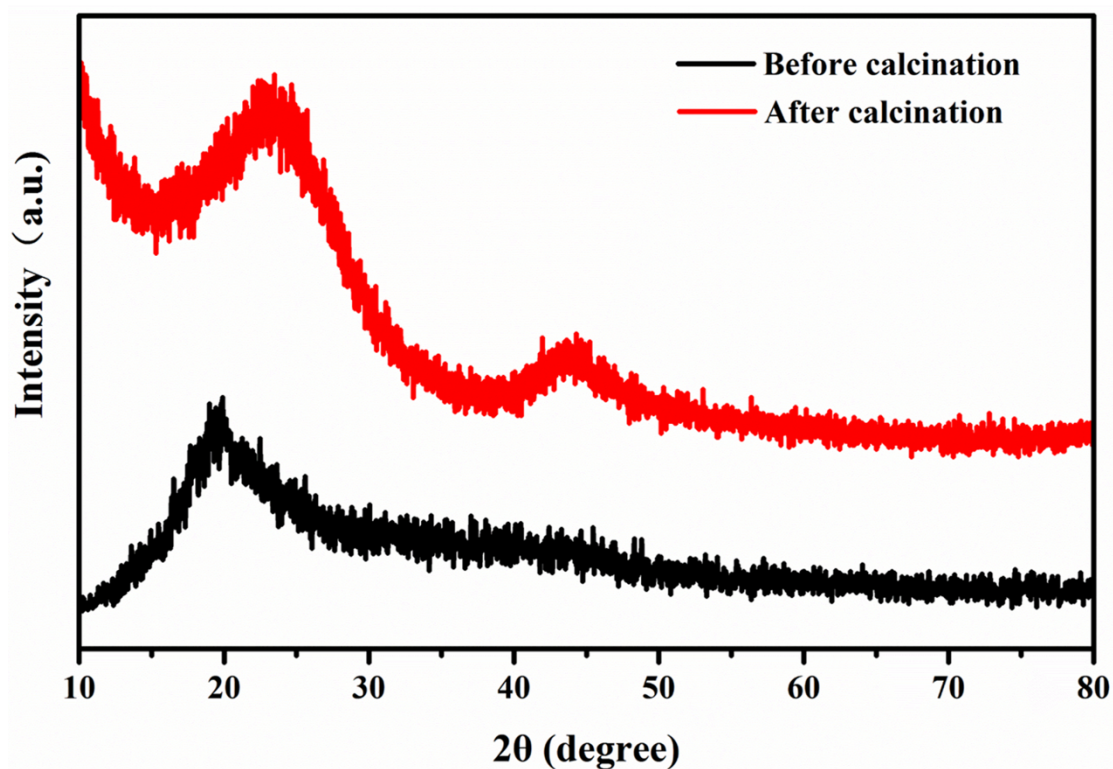


Figure S4. XRD patterns of the conidia before and after calcination

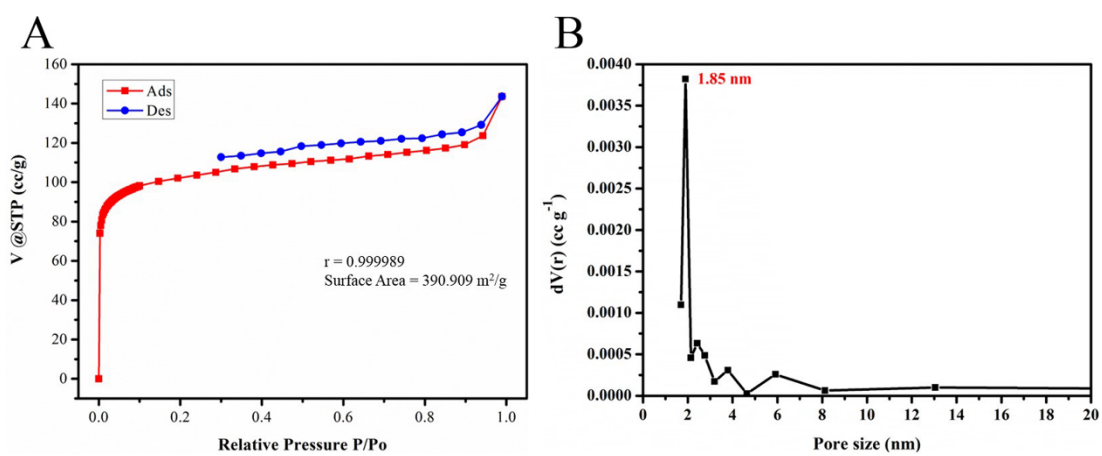


Figure S5. (A) N_2 adsorption–desorption isotherms and specific surface area of the calcinated conidia; (B) Pore size distribution of the calcinated conidia.

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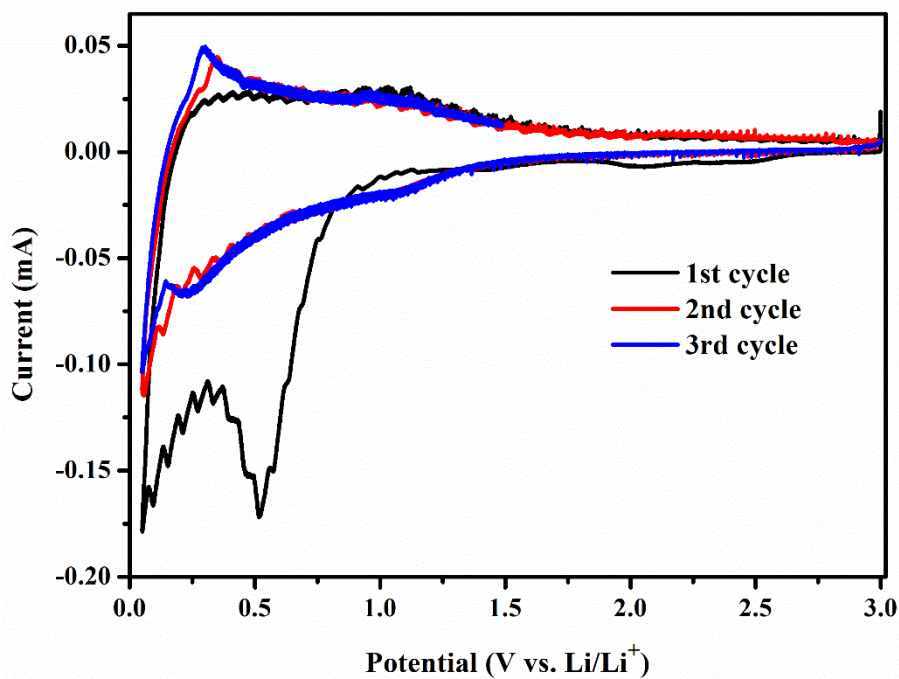


Figure S6. CV curves at a scan rate of 0.05 mV s⁻¹

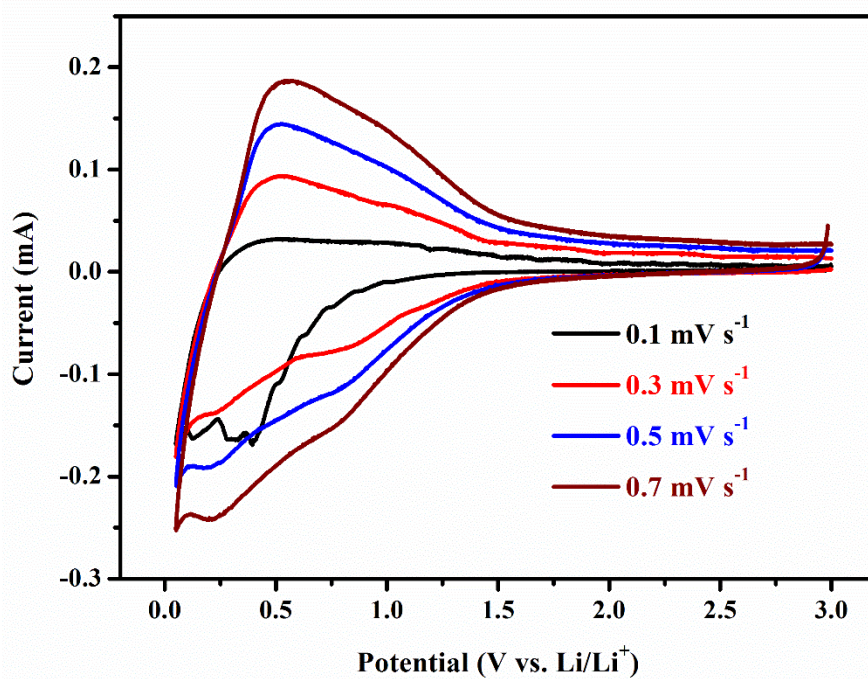


Figure S7. CV curves at the different scan rate

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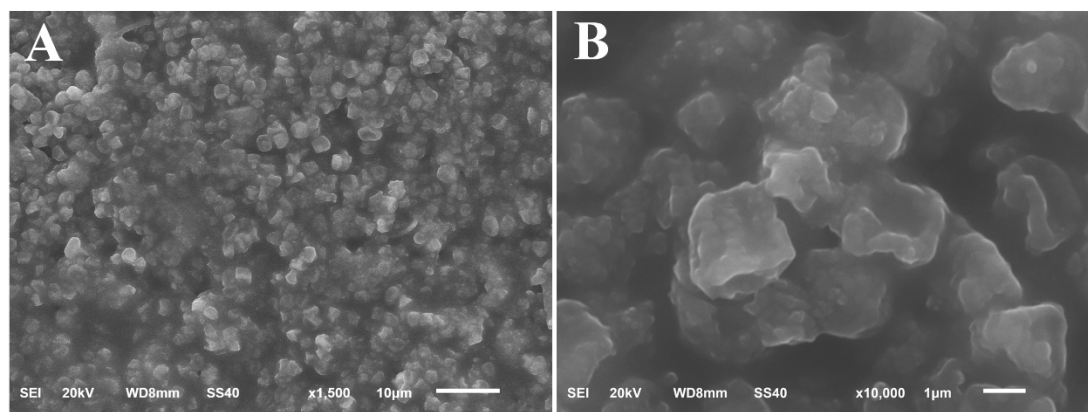


Figure S8. SEM images of conidia with different magnification after electrochemical cycling at 200 mA g^{-1} for 500 cycles.