Electronic Supplementary Information

Nitrogen enriched mesoporous carbon as high capacity cathode in lithium-oxygen batteries

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Experimental Section:

Preparation of nitrogen enriched mesoporous carbon (N-MCS): The nitrogen enriched carbon material was prepared by using a facile hard template method with melamine-formaldehyde resin as carbon precursor and silica sol as the template according to the literature[1]. Briefly, melamine (3.15 g) was firstly added into the mixture of formaldehyde solution (5 mL, 37 wt %) and deionized water (12.5 mL). Then, the PH was adjusted to 8.5 with Na_2CO_3 solution. Afterwards, the mixture was heated at 85 ℃ in a water bath with stirring to get a clear solution. Then, silica sol (30 mL, 5 wt %) was mixed with the solution after cooling down to 40 ℃. In order to initiate the condensation reaction, the PH was adjusted to 4.5 by the addition of 2 M HCl. The solution was kept static for 3 h to form a MF resin with silicon dioxide doped. The resin was dried and cured at 180 ℃ for 24 h, and then was pyrolyzed under N_2 atmosphere at 950 ℃ for 2 h. The silica template was removed by 20 % HF for 24 h. They were thoroughly washed in deionized water. Finally, the sample was

dried at 80 ℃, which was denoted as N-MCS. Commercial carbon material BP2000 (Cabot corporation, USA) was used for comparison.

Material characterizations: The morphology of carbon material was characterized by transmission electron microscopy (TEM, Tecnai G2 F20) equipped with EDX detector. Scanning electron microscopy (SEM) micrographs were taken on QUANTA 2000FEG to get the surface morphology of N-MCS air electrode.

N_2 adsorption isotherms were measured at 77.3K using an ASAP2010 system. Surface areas and pore volumes were determined using Brunauer-Emmett-Teller (BET) method. The pore size distribution curves were calculated from the desorption branches of nitrogen isotherms using the Barrett- Joyner-Halenda (BJH) model.

X-ray photoelectron spectroscopy (XPS) was carried out with a ESCALAB250 system utilizing Al K-alpha monochromatic (1486.6 eV) with a spot area of 500 μ m. The XPS spectra were peak fit and analyzed using XPeak4.1 (Photoelectron Spectroscopy Lab, Seoul National University).Spectra were calibrated according to the C1s (284.6 eV) peak.

The contact angle of two cathodes made of N-MCS and BP2000 respectively was tested on a JC2000A instrument (Shanghai Zhongchen Digital Technic Apparatus Co. Ltd., China) with a sessile drop method. 6 μL electrolyte was dropped on the surface of the electrodes with a microsyringe.

Air electrode preparation, lithium-oxygen battery construction and evaluation: N-MCS and BP2000 cathodes were prepared by mixing porous carbon material and PTFE as a binder with a weight ratio of 80/20. After solvent (ethanol) evaporation, the mixture was compressed and punched into disks with a diameter of 15 mm and then dried at 120℃ for 12 h. The carbon loading of each electrode was typically 6 mg.

Lithium-oxygen battery was constructed in an argon-filled glove box (H_2O＜0.1 ppm, O_2＜0.1 ppm). The cell consists of a 0.45 mm thick Li foil (16 mm in diameter) as anode, a carbon electrode as cathode and polypropylene fiber (Novatexx 2471 Freudenberg Filtration Technologies KG) soaked with electrolyte (1.0 M bis(trifluoromethane) sulfonamide lithium in TEGDME) as a separator. A stainless steel mesh was used as the current collector. All the cell parts were compressed

together to ensure good contact and the cell was completely sealed except for the O_2 entryway. After exposed to flow pure oxygen for 5 h, the Lithium-oxygen battery was discharged galvanostatically at a rate of 30 mA g^{-1} on a LAND 2100 system (Wuhan, China) with a cutoff voltage of 2 V.

Electrochemical impedance spectroscopy (EIS) characterizations: Electrochemical impedance spectroscopy (EIS) of the battery was measured in a frequency range of 106 HZ to 0.002 HZ using a Solarton 1287 test system. The measurement was conducted potentiostatically with perturbation amplitude of 10 mV under open circuit voltage (OCV) conditions. The measurements were made after exposed to flow pure oxygen for 5 h.

References

1. W. Li, D. Chen, Z. Li, Y. Shi, Y. Wan, G. Wang, Z. Jiang and D. Zhao, *Carbon*, 2007, **45**, 1757.