

Silver Nanoparticle-doped 3D Porous Carbon Nanofibers as Separator Coating for Stable Lithium Metal Anodes

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Section SI. Experimental Section

Materials: Polyvinyl alcohol (PVA, $M_w=74800 \text{ g mol}^{-1}$) was purchased from Changchun Chemical (Jiangsu) co., LTD (China). Polytetrafluoroethylene emulsion (PTFE, $M_w = 678.10 \text{ g mol}^{-1}$, 60 wt%) was from Jiangsu Transfar Technology co., LTD. Boric acid (BA) was from Tianjin Kermel Chemical Reagent (China). Silver nitrate (AgNO_3) (Purity: 99%) was purchased from Yingda (China). Sulfur (Purity: 99.9%) was purchased from Aladdin (China). The carbon nanotubes (CNTs) and carbon black (super-P) were from Shenzhen Nanoport, China. N-methylpyrrolidinone (NMP) and N,N-Dimethylformamide (DMF) was from Tianjin Kermel Co. Ltd. (China). LiNO_3 (Aldrich, 98%) was added into the electrolyte to improve stability of the Li metal interface. The copper (Cu) metal foil, Li metal foil, PVDF and commercial separator (PP) were from Shenzhen Lizhiyuan (China). The water used in this work was distilled water. All materials were purchased commercially and were used without further purification.

Characterization: The surface morphology changes of nanofibers by different treatments were examined with a field emission scanning electron microscope (FE-SEM; S-4800, Hitachico., Japan) after 2 min gold coating (E1045, Hitachi ion sputter, Japan). The distribution and situation of pores inside Ag-PCNFs composite were visualized with a 100 keV Hitachi H7650 transmission electron microscope (TEM). The surface elemental composition of fibers was analyzed using an X-ray photoelectron spectroscopy (XPS) (K-al phaX, Thermo Fisherco, USA). The crystalline phases of the samples were confirmed with X-ray diffraction (XRD) method using a Bruker AXS D8 Discover machine, and the diffraction angle 2θ was recorded from 10° to 80° with a Nifiltered $\text{CuK}\alpha$ radiation ($\lambda = 0.154 \text{ nm}$). Fourier transform infrared (FTIR) spectroscopy was performed on

TENSPR37 spectrometer (Bruker) range from 400 to 4000 cm^{-1} . The Electrical conductivity parameters were analyzed by ST-2722 Semiconductor resistivity of the powder tester (Suzhou Jingge Electronic Co., Ltd.) under the pressure condition of 14 MPa. The specific surface area was determined by the Brunauer-Emmett-Teller (BET) method.

Electrochemical measurements: The Li metal foil, Ag-PCNFs-PP and Cu metal foil were assembled in Li-Cu cells. Because the Cu electrode works, the Ag-PCNFs are placed between the PP and the copper. Two Li metal foil with Ag-PCNFs-PP were assembled as the working and counter electrodes in symmetrical cells. The sulfur cathode with sulfur loading of 0.76 mg cm^{-2} , Ag-PCNFs-PP and Li metal foil were employed in Li-S cells. Subsequently, 1 M bis (trifluoromethane) sulfonamide Li salt (Sigma Aldrich) and 0.1 M LiNO_3 in a mixture of 1, 3-dioxolane and 1, 2-dimethoxyethane (volume ratio of 1:1) were used as the electrolyte of batteries. The amount of electrolyte in the coin cell is 20 μL mg^{-1} . The galvanostatic charge/discharge tests of the batteries were conducted within the potential range of 1.8-2.8 V by using a LAND CT2001A battery-testing system. The electrochemical impedance spectroscopy (EIS) measurements were performed in the CHI660E electrochemical measurement system. The EIS was determined within the frequency range from 100 kHz to 0.05 Hz with an AC voltage amplitude of 5 mV at open-circuit voltage. The Li-Cu cells were tested at 1 mA cm^{-2} and 1 mAh cm^{-2} . The Li-Li cells were tested at a current density of 0.5 mA cm^{-2} with a total capacity of 0.5 mAh cm^{-2} . The charge and discharge current density was set to be 0.1 C, 0.2 C, 0.5 C and 1 C in Li-S cells. All electrochemical tests were conducted at room temperature and carried out at least five coin cells.

Section SII. Supporting Figures

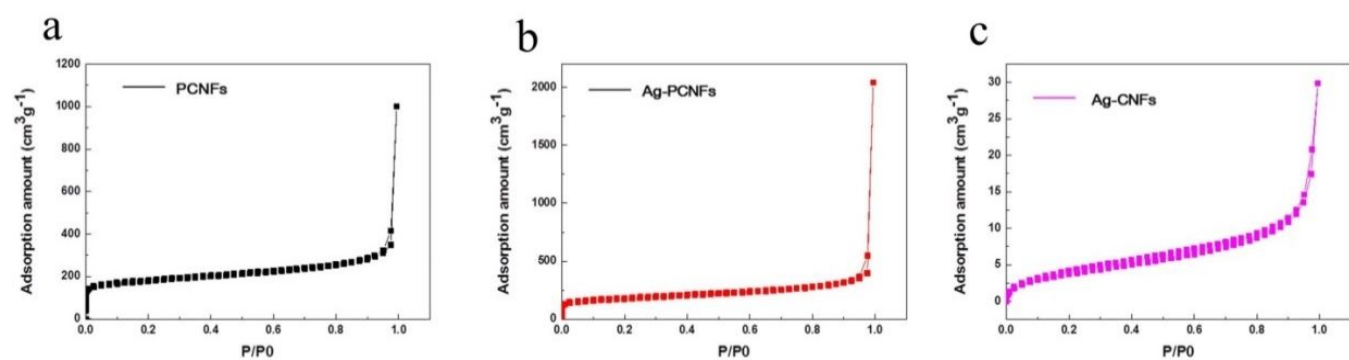


Figure S1 The pristine adsorption-desorption curves for a) PCNFs, b) Ag-PCNFs and c) Ag-CNFs.

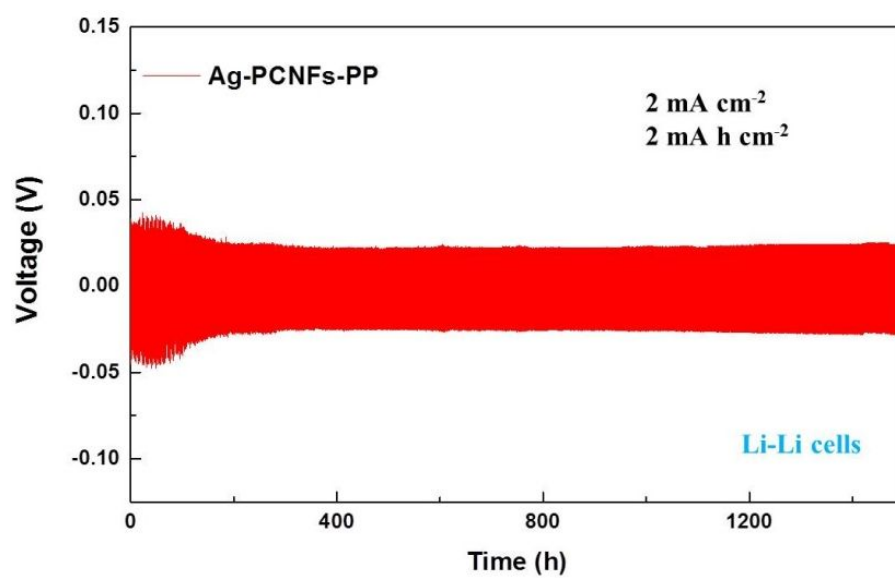


Figure S2 Voltage profile of the Li-Li cells with separator of Ag-PCNFs-PP at 2 mA cm⁻² and 2 mA h cm⁻².

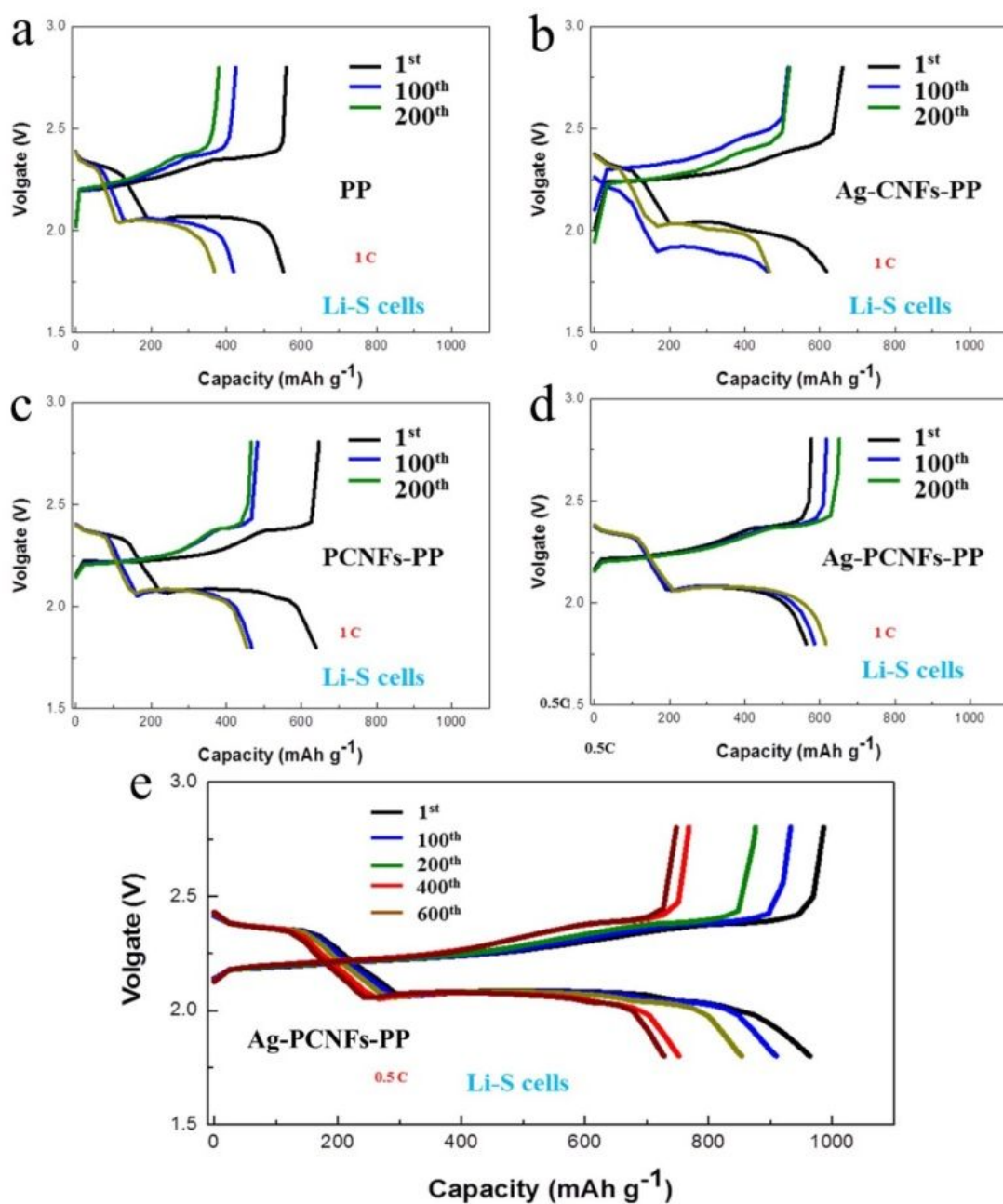


Figure S3 The charge-discharge curves of a) PP, b) Ag-CNFs-PP, c) PCNFs-PP and d) Ag-PCNFs-PP at 1 C. e) The charge-discharge curves of Ag-PCNFs-PP at 0.5 C.

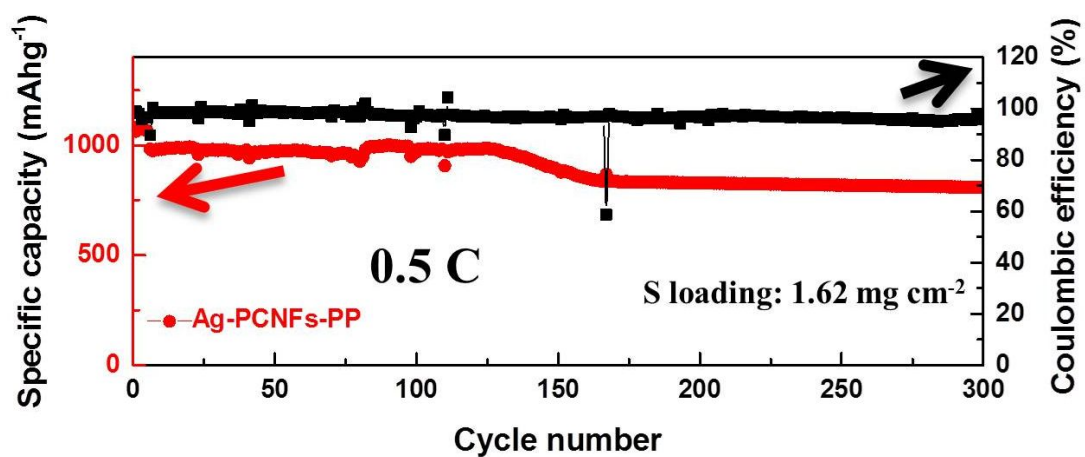


Figure S4 Discharge capacity and Coulombic efficiency at 0.5 C of the Li-S cells with Ag-PCNFs with 1.62 mg cm^{-2} sulfur loading.

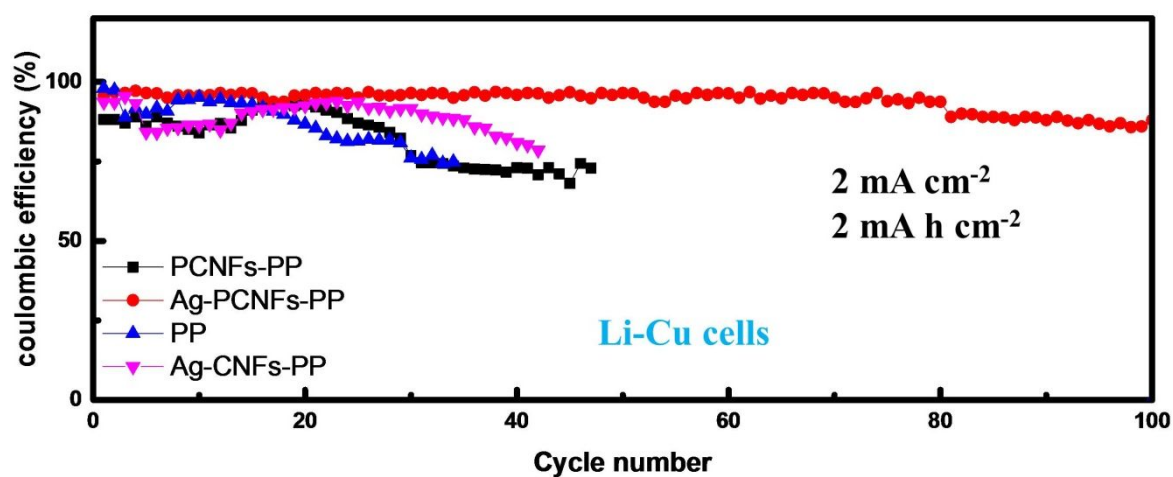


Figure S5 Coulombic efficiencies of the Li-Cu cells with Ag-PCNFs-PP at 2 mA cm⁻² and 2 mA h cm⁻².