

Electronic Supplementary Information for

Anchovy-derived nitrogen and sulfur co-doped porous carbon materials for high-performance supercapacitors and dye-sensitized solar cells

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Preparation of counter electrodes. 0.1 wt % of AnC powders were homogeneously dispersed in 2-propanol solution by ultrasonication for 30 min. The resultant solution was deposited directly onto FTO/glass (TEC-8, Pilkington) using an electrospray technique. First, the dispersed AnC solutions were loaded into a plastic syringe with a 27-gauge stainless steel hypodermic needle. The needle was connected to a high voltage power supply (ESN-HV30). A voltage of ~ 4.8 kV was applied between a metal orifice and the conducting substrate at a distance of 6 cm. The feed rate was controlled by a syringe pump (KD Scientific Model 220) at a constant flow rate of 30 $\mu\text{L min}^{-1}$. The electric field overcame the surface tension of the droplets, resulting in minimization of the size of the numerous charged mist particles. The sample electrodes were sintered at 300 °C for 30 min in air prior to device fabrication. For the

reference, the Pt-FTO electrode was also prepared by deposition of *ca.* 30 $\mu\text{L cm}^{-2}$ of H_2PtCl_6 solution (2 mg of H_2PtCl_6 in 1 mL of ethanol) and sintered at 400 °C for 15 min.

Fabrication of symmetrical dummy cells. Symmetrical sandwiched dummy cells were fabricated with two identical **AnC-900-2.0-** and Pt-FTO sheets, which were separated by 25 μm -thick Surlyn (Solaronix, Switzerland) tape as a sealant and spacer, leaving an active area of $0.6 \times 0.6 \text{ cm}^2$. The sheet edges were coated using an ultrasonic soldering system (USS-9200, MBR Electronics) to improve the electrical contacts. The electrolyte solution was prepared with 0.22 M $\text{Co}(\text{bpy})_3(\text{BCN}_4)_2$, 0.05 M $\text{Co}(\text{bpy})_3(\text{BCN}_4)_3$, 0.1 M LiClO_4 , and 0.8 M 4-*tert*-butylpyridine in acetonitrile. Co-complexes were prepared by a reported procedure. Electrolyte solution was introduced through a drilled hole on the CEs via vacuum back filling. The hole was sealed with a cover glass using a Surlyn seal.

Electrochemical analysis. All electrochemical measurements for electrocatalytic evaluation of materials were carried out with VersaSTAT 3 (Version 1.31), AMETEK, connected to a potentiostat under dark conditions at room temperature. EIS spectra were acquired in the frequency range from 1×10^6 to 0.1 Hz at an open circuit voltage of 0 V and AC modulation amplitude of 10 mV. The EIS data analysis was processed using Zplot/Zview2 software.

Fabrication and characterization of DSSCs. FTO plates were cleaned in detergent solution, water, and ethanol using an ultrasonic bath. FTO substrates were immersed in 40 mM aqueous TiCl_4 solution at 70 °C for 30 min and washed with water and ethanol. TiO_2 colloidal paste (Dyesol, 18NR-T) was screen-printed onto FTO/glass and sintered at 500 °C

for 30 min in air. The thickness of the transparent layer was measured by using an Alpha-step 250 surface profilometer (Tencor Instruments, San Jose, CA), and a paste for the scattering layer containing 500 nm size anatase particles (ENB Korea, STP-500N) was deposited by doctor blade printing and then dried for 2 h at 25 °C. TiO₂ electrodes were sintered at 500 °C for 30 min. The resulting TiO₂ photoanode was immersed in THF/ethanol (1:2, v/v) solution containing 0.2 mM of SM-315 sensitizer with 0.6 mM CDCA and then kept at room temperature for 4 h. The dye-adsorbed TiO₂ photoanodes were assembled with **AnC-900-2.0** or Pt CEs using a thermal adhesive film (25 μm thick Surlyn, Du-Pont) as a spacer to produce a sandwich-type cell. Electrolyte solution was introduced through a drilled hole on the CEs via vacuum backfilling. The hole was sealed with a cover glass using Surlyn. The light intensity was adjusted with an Si solar cell that was doubled-checked with an NREL-calibrated Si solar cell (PV Measurement Inc.). The applied potential and measured cell current were measured using a Keithley model 2400 digital source meter. Photoelectrochemical data were measured using a 1000-W xenon light source (Oriel, 91193) that was focused to give 100 mW cm⁻² (1 sun at AM 1.5G). The *J-V* characteristics of the cell under these conditions were determined by biasing the cell externally and measuring the generated photocurrent. This process was fully automated using Wavemetrics software. The measurement settling time between applying a voltage and measuring a current for the *J-V* characterization of DSSCs was fixed at 80 ms.

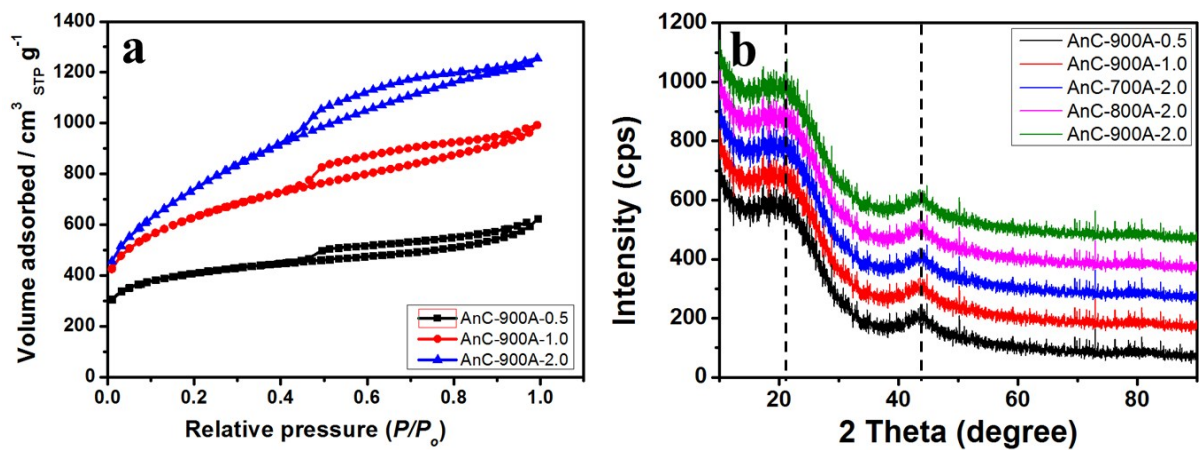


Fig. S1 (a) Nitrogen sorption isotherm data of **AnC-900-2.0** using different mass ratios of KOH (0.5, 1.0, and 2.0 wt %). (b) Powder X-ray diffraction (XRD) patterns of **AnC** samples.

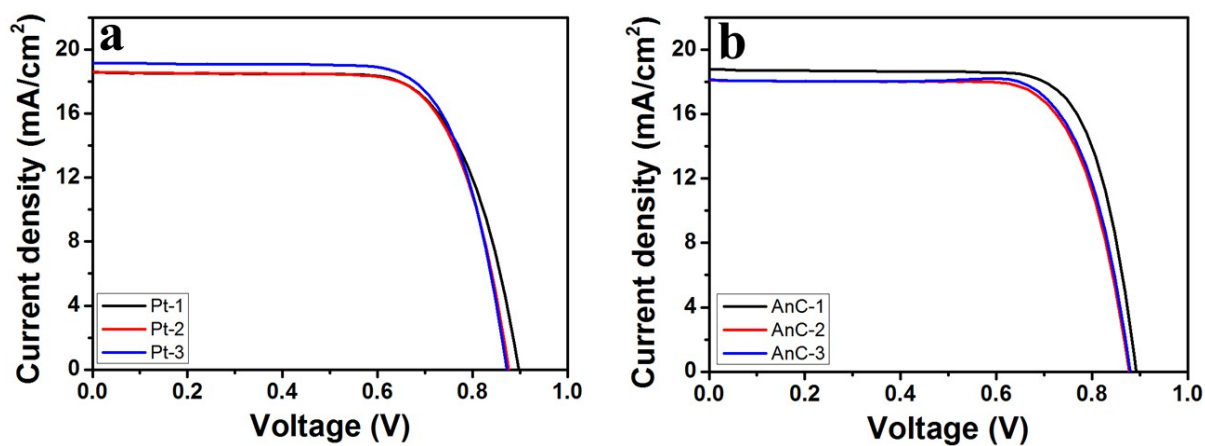


Fig. S2 Current–voltage characteristics of the DSSCs with Pt (a) and **AnC-900-2.0** (b) CEs.

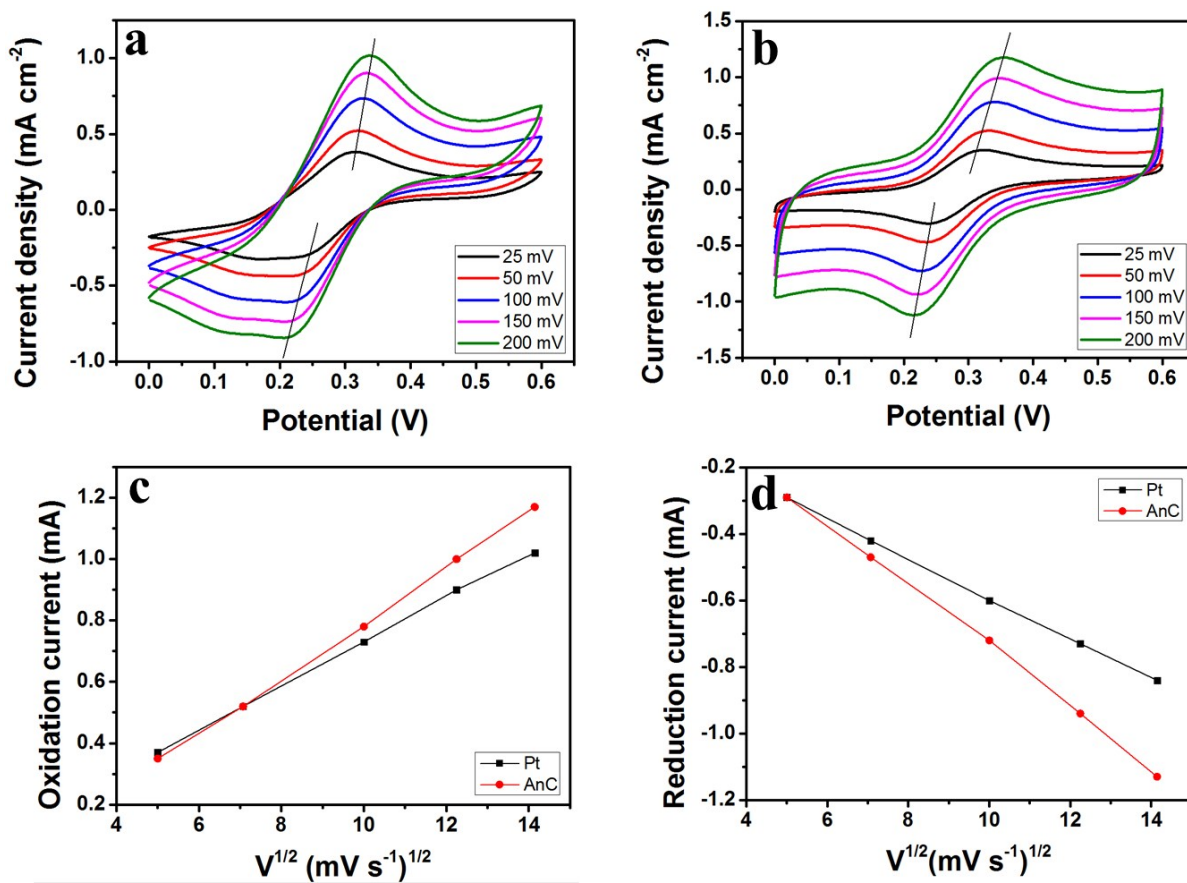


Fig. S3 Cyclic voltammograms of a symmetrical dummy cell by using two identical Pt (a) and AnC-900-2.0 (b) cathodes in Co(bpy)₃^{2+/3+} with various scan rates. The oxidation (c) and reduction (d) peak current with respect to the square root of scan rate.

Table S1 Photovoltaic performance of the DSSCs with AnC-900-2.0 and Pt CE

CE	Dye/electrolyte	R _S (Ω cm ²)	R _{CT} (Ω cm ²)	J _{SC} (mA/cm ²)	V _{OC} (mV)	FF (%)	PCE (%)
Pt-1				18.583	897.521	71.27	11.89
Pt-2	SM-315/Co(bpy) ₃ ^{2+/3+}	3.87	14.71	18.604	876.259	72.76	11.86
Pt-3				19.173	872.269	73.11	12.23
AnC-1				18.784	892.641	75.88	12.72
AnC-2	SM-315/Co(bpy) ₃ ^{2+/3+}	3.00	7.56	18.110	878.022	73.96	11.76
AnC-3				18.138	880.035	75.00	12.00

