Supporting Information

Extremely Durable Supercapacitor Enabled by Disordered Porous Carbon with a Capacity Retention up to 60,000 Cycles

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Experimental Section

Materials and Chemicals:

Citric acid monohydrate ($C_6H_8O_7 \cdot H_2O$) and sodium chloride (NaCl) were purchased from Meryer, while potassium hydroxide (KOH) was sourced from Aladdin. Polytetrafluoroethylene dispersion (PTFE, D210C) and acetylene black were procured from Taiyuan LZY Technology Co., Ltd. All the water utilized in the present study is deionized water.

Preparation of C-T:

Synthesis of C-900: $C_6H_8O_7 \cdot H_2O$ (2.9 mmol, 0.613 g) was mixed in water (100 mL) under continuous stirring at room temperature until precipitation was completed. Subsequently, the resulting precipitation was subjected to freeze-drying, thereby obtaining white powders. The precursor was directly carbonized in a N_2 atmosphere at 900 °C for 2 h. The mixtures were collected by filtration using commercial filter paper and thoroughly washed with deionized water. Thereafter, they were placed in an oven and dried at 50 °C for 48 h. The product was named C-900.

Synthesis of HC_2-900: $C_6H_8O_7 \cdot H_2O$ (2.9 mmol, 0.613 g) and varying amounts of NaCl (21.3, 25.6 and 29.9 mmol, respectively) were thoroughly blended at room temperature for 10 minutes. Subsequently, the mixtures were subjected to freeze-drying for 96 h. The resultant composites were pyrolyzed in a N_2 atmosphere at 900 °C for 2 h. The prepared samples are denoted as HC_x-900, where x represents the mole ratio of NaCl (x = 21.3, 25.6 and 29.9 mmol, while $C_6H_8O_7 \cdot H_2O$ is maintained at 2.9 mmol).

Characterizations:

The morphologies of samples were characterized via a field emission scanning electron microscope (SEM, Sigma500, ZEISS, Germany) and transmission electron microscopy (TEM, JEM F200, JEOL, Japan). Fourier transform infrared (FTIR) spectra were analyzed with a Shimadzu spectrometer, in a frequency range of 4000-500 cm^{-1}. The elemental mapping and content were characterized using energy dispersive spectrometer (EDS, UltimMax 40e, CIQTEK, China). The surface species and chemical states were measured by X-ray photoelectron spectroscopy (XPS, ES-CALAB 250Xi, Thermo Fisher Scientific, USA). The crystallographic structure of samples was characterized using X-ray powder diffraction (XRD, DX-2700BH, Haoyuan Instrument, China), with the samples being scanned from 10 to 90°. Raman spectra (DXR, Thermo Fisher Scientific, USA) were employed to characterize the phase compositions with a laser wavelength of 532 nm. The N_2 adsorption-desorption isotherms were collected on machine (ASAP 2420, Micrometrics, USA) at 77.350 K.

Electrochemical measurements:

Three-electrode system: cyclic voltammetry (CV), galvanostatic charge-discharge (GCD) and electrochemical impedance spectroscopy (EIS) curves of all samples were conducted on an electrochemistry workstation system (CHI 660E, CH Instruments Inc.) in a typical three-electrode system. In the test, a Pt foil serves as the counter electrode, a Hg/HgO electrode acts as the reference electrode, and 6 M KOH aqueous solution is employed as the electrolyte.

The working electrode was prepared as follows: the samples, carbon black, and polytetrafluoroethylene are thoroughly ground in an ethanol/water mixture at a ratio of 8:1:1. The resulting slurry is pressed into nickel foam (1×1 cm^2), and then dried at 50 °C for 12 h. Subsequently, it is pressed on a tablet press at a pressure of 10 MPa for 1 minute, and then placed in an oven for another 12 h of drying at 50 °C.

CV tests were conducted a potential window of -1.1~0 V at a scan rate of 100 mV s^{-1}. GCD tests were evaluated at different current densities ranging from 1 to 20 A g^{-1}. The EIS plot was recorded over the frequency range of 100000-0.01 Hz with a 5 mV sinusoidal voltage at open circuit potential. The specific capacitance of electrodes (C_s, F g^{-1}) was calculated from the discharge curves according to the following equation:

$$Cs = \frac{I\,\Delta t}{m\,\Delta V}$$

where I (A) denotes the constant current, Δt (s) is the discharge time, ΔV (V) represents the absolute discharge potential window, and m (g) corresponds to the total mass of the samples.

For the test of two-electrode system, a symmetrical two-electrode device was fabricated in 1 M Na_2SO_4 electrolyte with a potential window from 0 to 2 V. The specific capacitance of electrode (C_g, F g^{-1}), the energy density E (Wh kg^{-1}), power density P (W kg^{-1}) of the devices were calculated using the following equations:

$$Cg = \frac{4I\Delta t}{m\,\Delta V}$$

$$E = \frac{C\,\Delta V^2}{2}$$

$$P = \frac{E}{\Delta t}$$

where I (A) represents the constant current, Δt (s) is the discharge time, ΔV (V) signifies the absolute discharge potential window, m (g) corresponds to the total mass of the samples, and C (F g^{-1}) indicates the capacitance.

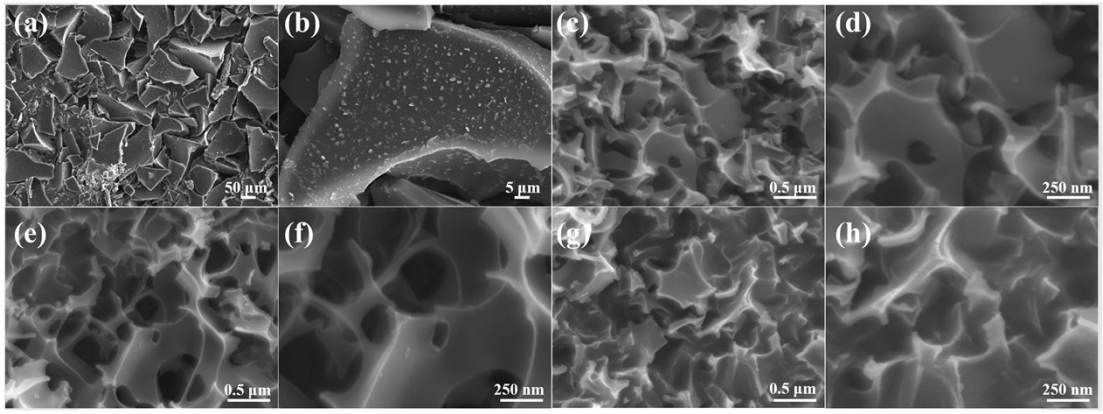

Figure S1. SEM images of samples (a-b) C-900, (c-d) HC_1-900, (e-f) HC_2-900, (g-h) HC_3-900.

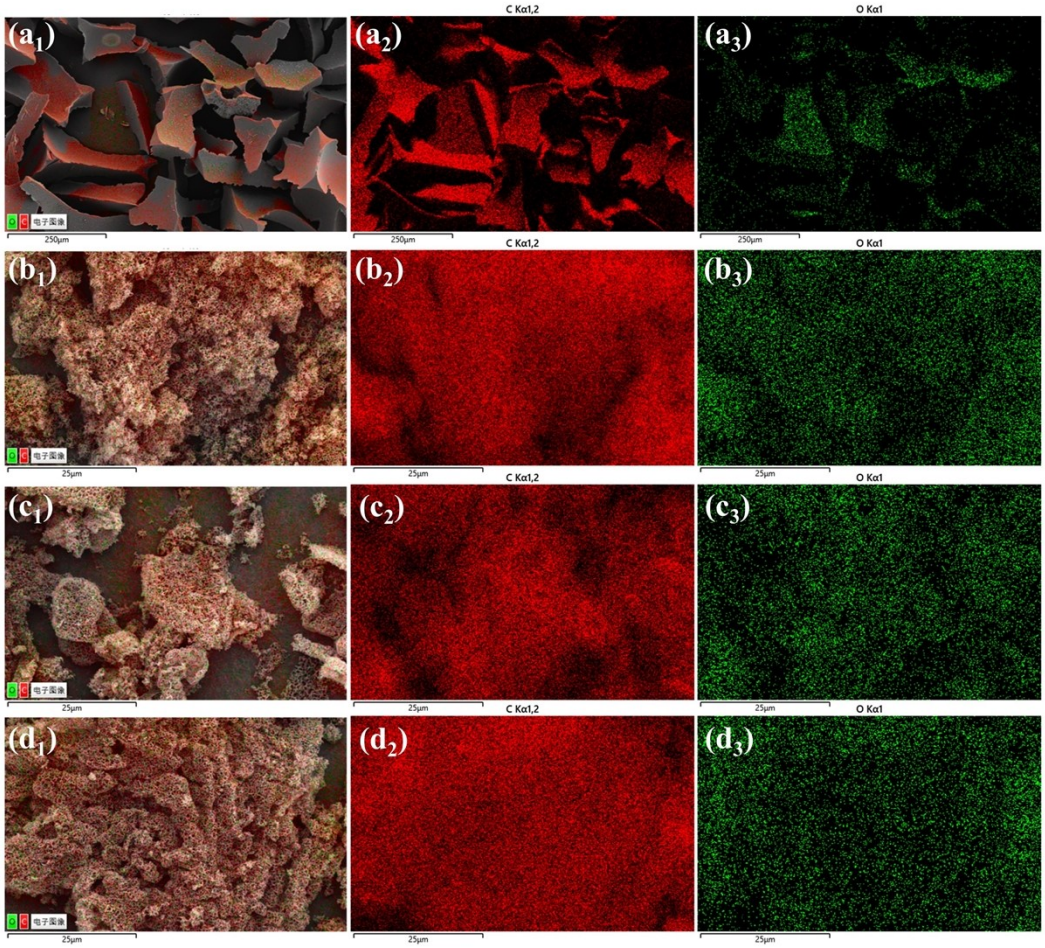

Figure S2. EDS mapping of samples (a_1-a_3) C-900, (b_1-b_3) HC_1-900, (c_1-c_3) HC_2-900 and (d_1-d_3) HC_3-900.

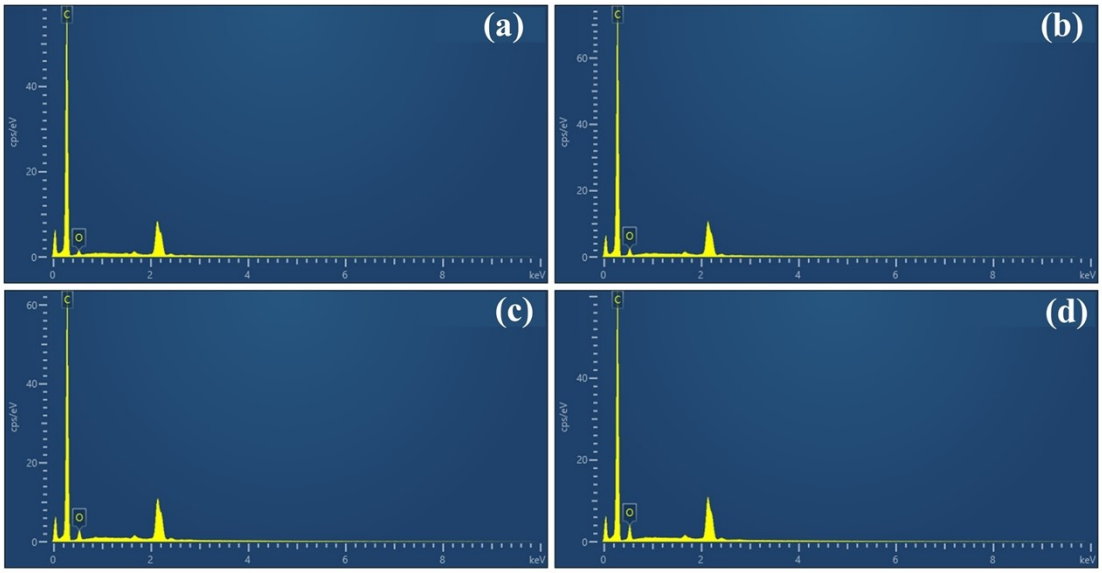

Figure S3. EDS curve of samples (a) C-900, (b) HC_1-900, (c) HC_2-900 and (d) HC_3-900.

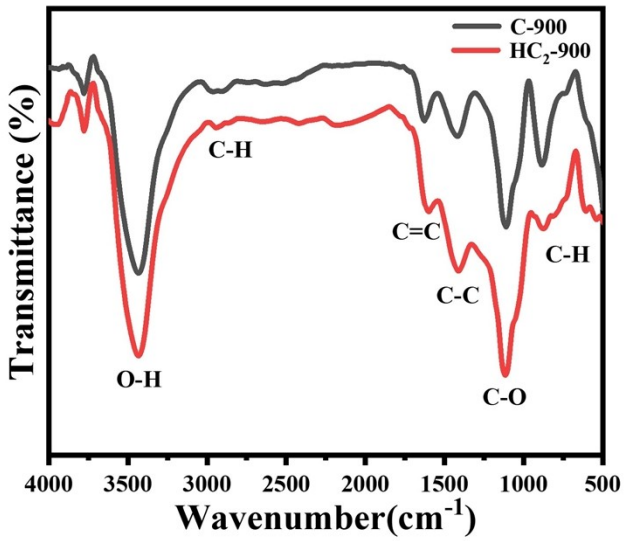

Figure S4. FTIR spectrum of samples C-900 and HC_2-900.

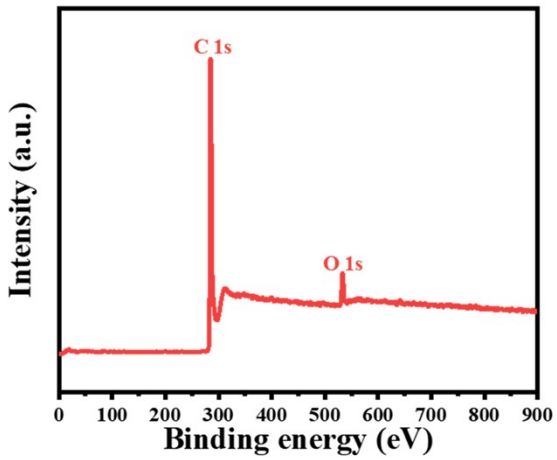

Figure S5. XPS survey spectrum of sample HC_2-900.

Table S1. Chemical compositions of all samples.

Sample	C (*wt%*)	O (*wt%*)
C-900	95.87	4.13
HC_1-900	93.74	6.26
HC_2-900	**91.95**	**8.05**
HC_3-900	88.77	11.23

Table S2. Overview of the cycling stability of typical symmetric supercapacitors based on carbon electrodes ever reported.

Electrode materials	Current density (A g^{-1})	Cycle number	Retention (%)	Rf.
NBC-100	2	5000	95	1
GPC-900-1h	5	10000	90	2
NS-HPLC-K	5	10000	99.8	3
HPCs-60	10	20000	89.9	4
MG-18	0.1	2500	84.8	5
O-PCN-20	10	20000	86.2	6
N-MHCNs-2	5	3000	90	7
CPC-2	5	3000	76	8
$C_{800}K_{0.4}$	5	10000	94.83	9
NCO/GQDs-10%	1	3000	93	10
HC_2-900	**4**	**60000**	**98.2**	**This work**

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