3D hierarchical porous carbon matching ionic liquid with ultrahigh specific surface area and appropriate porous distribution for supercapacitors

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1. Electrochemical Measurements

The complex form of capacitance C(ω) is dependent on the real part of the capacitance C′(ω) and the imaginary part of the capacitance C″(ω), which is defined as follows

$$C(\omega) = C'(\omega) - jC''(\omega) \quad (1)$$

$$C'(\omega) = \frac{-Z''(\omega)}{\omega\left|Z(\omega)\right|^2} \quad (2)$$

$$C''(\omega) = \frac{Z'(\omega)}{\omega\left|Z(\omega)\right|^2} \quad (3)$$

where Z′(ω) is the real component and Z″(ω) is the imaginary component of the complex impedance, respectively. The angular frequency ω is determined by ω = 2πf. τ_0 is the relaxation time constant which is calculated by $\tau_0 = 1/f_0$

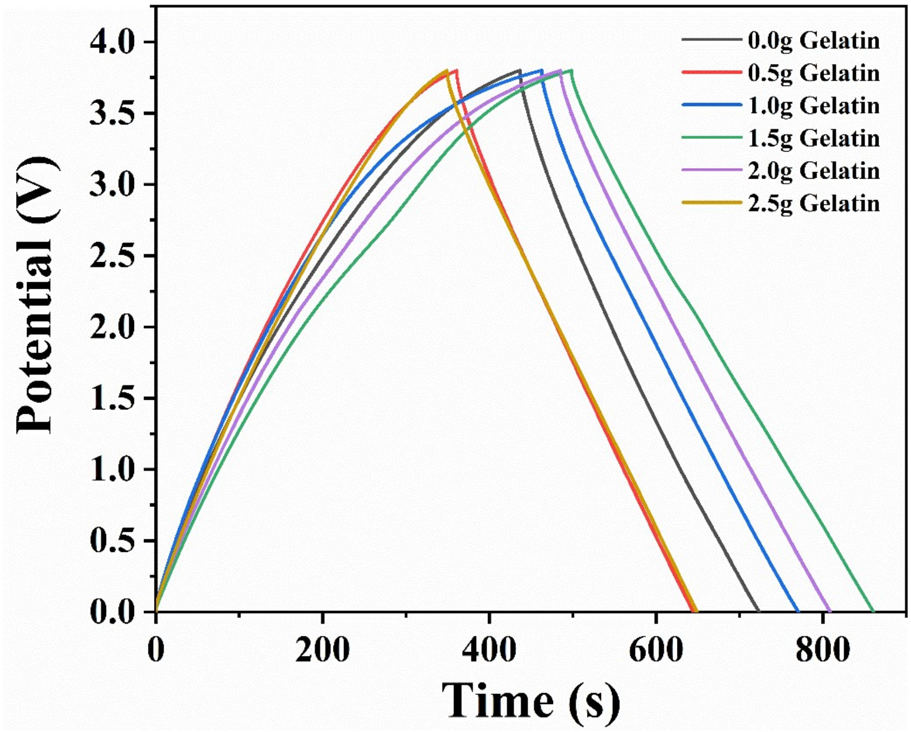

Fig. S1. Galvanostatic charge-discharge (GCD) curves for different dosage of gelatin at 1 A g^{-1}.

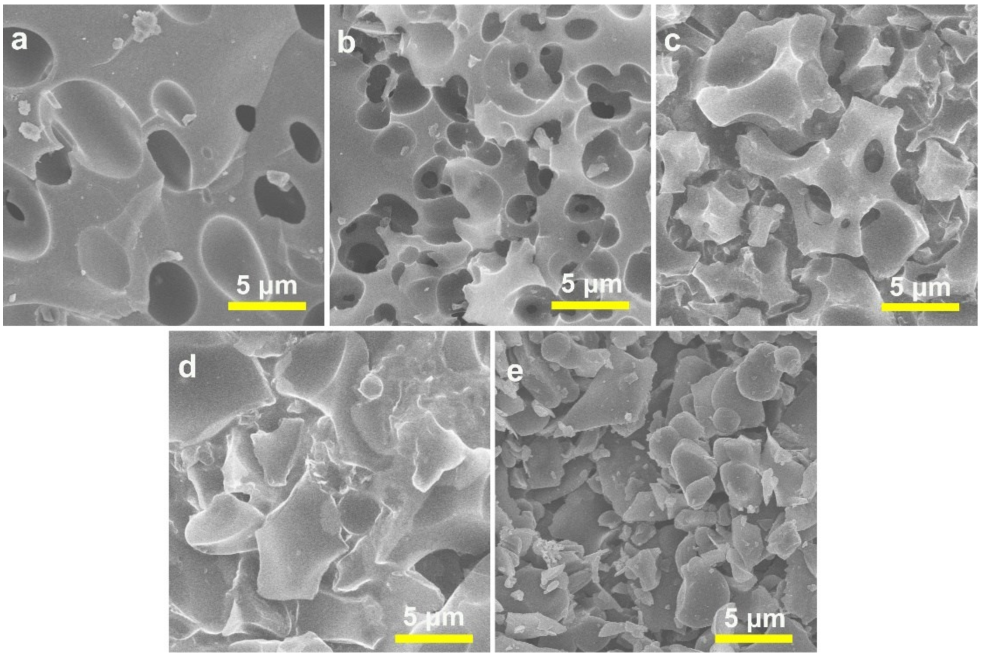

Fig. S2. Morphology characterization of HPC: a) SEM image of HPC-0; b) SEM image of HPC-1.0; c) SEM image of HPC-2.0; d) SEM image of HPC-3.0; e) SEM image of HPC-4.0.

Table S1 The contents of C element, N element and O element from XPS survey spectra.

Sample	C%	N%	O%
HPC-0	76.44	3.93	19.63
HPC-0.5	83.79	5.46	10.75
HPC-1.0	88.31	2.79	8.90
HPC-1.5	88.54	2.60	8.86
HPC-2.0	86.15	2.55	11.30
HPC-2.5	86.99	2.63	10.38
HPC-3.0	85.48	3.30	11.22
HPC-3.5	83.46	3.15	13.39
HPC-4.0	84.40	3.11	12.49

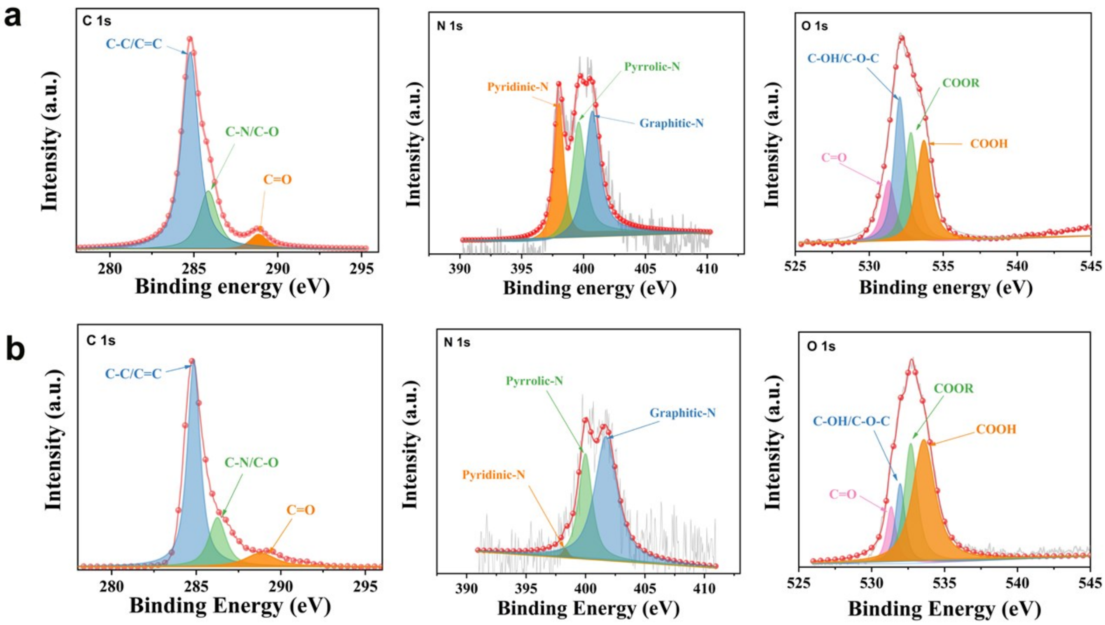

Fig. S3 XPS survey spectra: a) C 1s, N 1s, O 1s spectra of HPC-0; b) C 1s, N 1s, O 1s spectra of HPC-3.5.

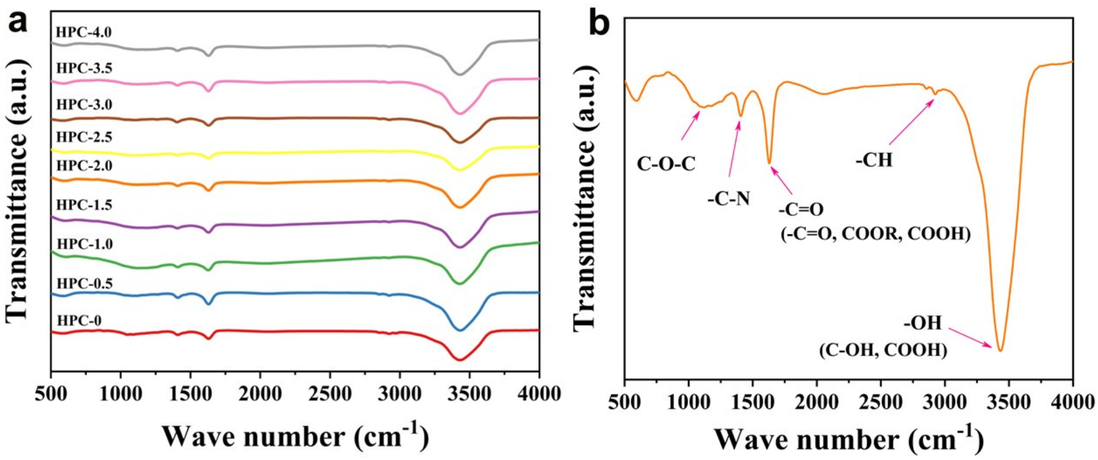

Fig. S4 IR spectroscopy: a) IR spectra of all HPCs; b) IR spectra of HPC-3.5.

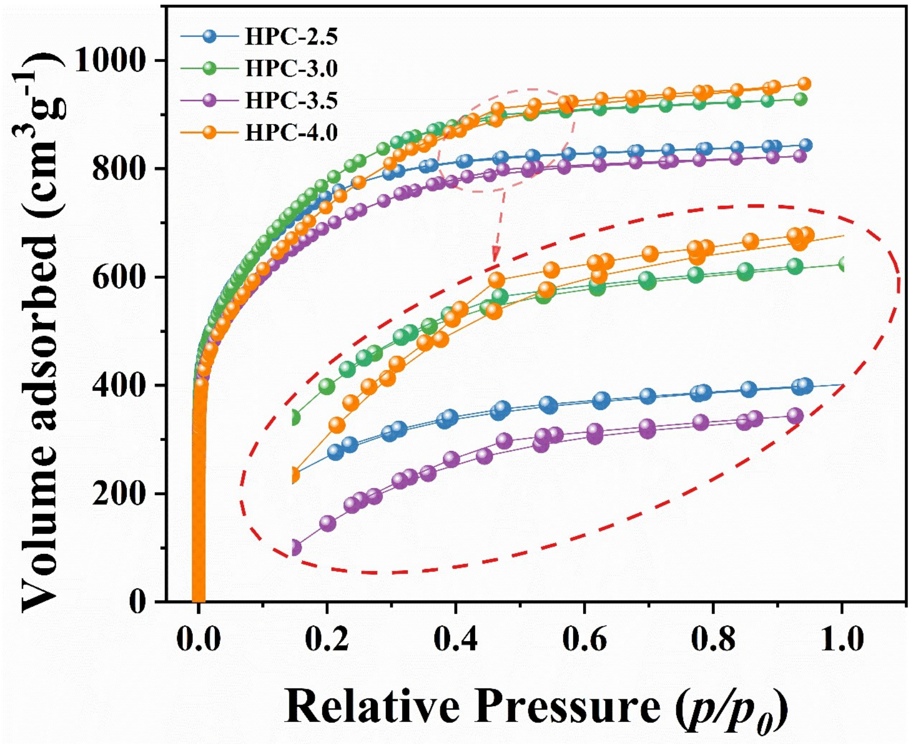

Fig. S5 Magnification of N_2 adsorption−desorption isotherms.

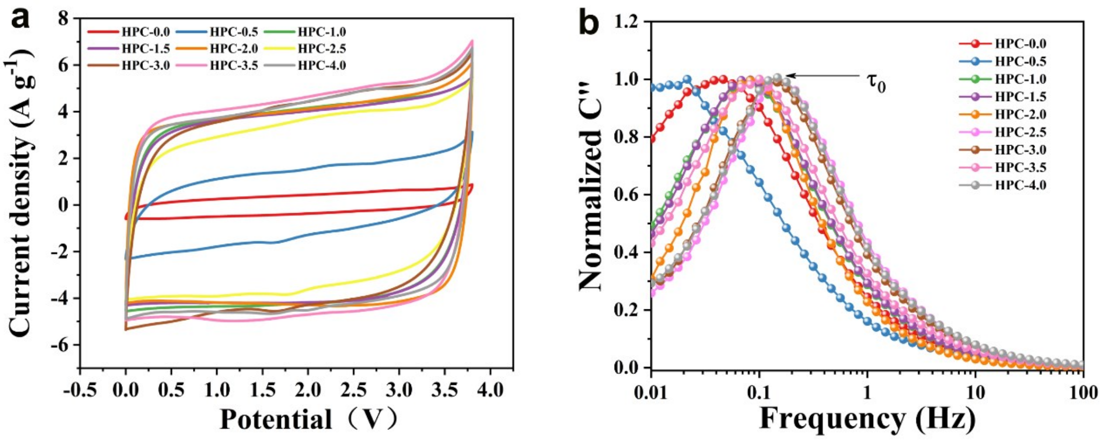

Fig. S6 a) Cyclic voltammetry (CV) curve of all HPC materials at scan rates of 50 mv s^{-1}. b) The normalized imaginary part capacitances of all HPC materials.

The same conclusions can be obtained from Fig. S7b as from Fig. 5c: HPC-3.5 has a larger τ_0 than HPC-3.0 and HPC-4.0 dominated by mesopores, due to a good matching of the micropores size with $EMIMBF_4$ electrolyte.

Table S2 Summary of the supercapacitive performance of representative porous carbon electrodes in ionic liquid electrolytes.

Material	IL	Voltage window	Specific capacitance	Reference
mesoporous carbon nanosheets	$EMIMBF_4$	3.5 V	130 F g^{-1} at 1 A g^{-1}	2
mesoporous activated carbon fibers	$EMIMBF_4$	4 V	204 F g^{-1} at 0.5 A g^{-1}	3
porous carbon nanosheets	$EMIMBF_4$	3 V	173 F g^{-1} at 0.25 A g^{-1}	4
ordered mesoporous and microporous carbons	$EMIMBF_4$	3.5 V	138 F g^{-1} at 0.1 A g^{-1}	5
3D cross coupled macro-mesoporous carbon	$EMIMBF_4$	4 V	166 F g^{-1} at 0.5 A g^{-1}	6
salt-templated carbon materials	$EMIMBF_4$	3.5 V	178 F g^{-1} at 0.2 A g^{-1}	7
porosity adjustable graphene monoliths	$EMIMBF_4$	4 V	172 F g-1 at 0.2 A g^{-1}	8
N, S dual-doped ordered mesoporous carbon/MnO_2	$EMIMBF_4$	3.5 V	200 F g^{-1} at 2 mV s^{-1}	9
enteromorpha derived carbons	$EMIMBF_4$	3 V	201 F g-1 at 1 A g-1	10
hierarchical porous honeycomb-like carbon	$EMIMBF_4$	3.5	174 F g^{-1} at 1 A g^{-1}	11
highly porous carbon	$EMIMBF_4$	4 V	224 A g^{-1} at 0.1 A g^{-1}	12
HPC	$EMIMBF_4$	3.8 V	216.5 A g^{-1} at 1 A g^{-1}	This work

Table S3 Summary of energy density and power density of symmetric supercapacitors in ionic liquid electrolytes.

Material	Energy density	Power density	References
mesoporous carbon nanosheets	55.3 Wh kg^{-1} 46 Wh kg^{-1}	0.87 kW kg^{-1} 236 kW kg^{-1}	2
mesoporous activated carbon fibers	113 Wh kg^{-1} 9.2 Wh kg^{-1}	1 kW kg^{-1} 83 kW kg^{-1}	3
porous carbon nanosheets	54.1 Wh kg^{-1} 25.4 Wh kg^{-1}	0.375 kW kg^{-1} 15 kW kg^{-1}	4
ordered mesoporous and microporous carbons	59 Wh kg^{-1} 25 Wh kg^{-1}	0.1 kW kg^{-1} 18 kW kg^{-1}	5
3D cross coupled macro-mesoporous carbon	92 Wh kg^{-1} 39 Wh kg^{-1}	1 kW kg^{-1} 200 kW kg^{-1}	6
salt-templated carbon materials	76 Wh kg^{-1} 39 Wh kg^{-1}	0.2 kW kg^{-1} 9 kW kg^{-1}	7
enteromorpha derived carbons	62 Wh kg^{-1} 24 Wh kg^{-1}	0.75 kW kg^{-1} 60 kW kg^{-1}	10
hierarchical porous honeycomb-like carbon	79 Wh kg^{-1} 64 Wh kg^{-1}	0.87 kW kg^{-1} 19.5 kW kg^{-1}	11
nanofibrous chitin microspheres	58.7 Wh kg^{-1} 38 Wh kg^{-1}	0.3 kW kg^{-1} 7.1 kW kg^{-1}	13
N, O co-doped honeycomb porous carbon	94.1 Wh kg^{-1} 42.5 Wh kg^{-1}	0.35 kW kg^{-1} 17.5 kW kg^{-1}	14
3D hierarchical porous carbon materials	46.8 Wh kg^{-1} 22.9 Wh kg^{-1}	6.2 kW kg^{-1} 25.4 kW kg^{-1}	15
HPC	108.6 Wh kg^{-1} 42.8 Wh kg^{-1}	0.96 kW kg^{-1} 76.4 kW kg^{-1}	This work

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