Mild Chemical-Activated Durian peels Biomass-derived Hydrothermal Porous Carbon for Electrochemical Supercapacitor

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Table S1 Pore characteristics of the PCs

samples	Specific surface area (m^2 / g)	Micropore surface area	Total pore volume (cm^3 / g)	Micropore volume (cm^3 / g)	Mesopore volume (cm^3 / g)	Average pore diameter (nm)	Micropore volume / Mesopore volume ratios
APC	1995.3	1749.054	0.958	0.8536	0.1044	1.92	8.18
APC-Fe-5%	1883.6	1678.566	0.948	0.8274	0.1206	2.01	6.86
APC-Fe-10%	2100.5	1864.302	1.063	0.9249	0.1381	2.02	6.69
APC-Fe-20%	1251	899.195	0.6193	0.5291	0.0902	1.98	5.86
HPC-Fe-10%	370.1	180.21	0.2346	0.1396	0.095	2.53	1.47

The specific surface areas were calculated using the BET method.
Micropore surface area form t-plot method.
Micropore volume determined by the t-plot method.
Total pore volume at p/p0~0.99.
Average pore diameter.

Table S2 Atomic % of the APC-Fe-10%

samples	Atomic % (C)	Atomic % (O)	Atomic % (N)	Atomic % (Fe)
APC-Fe-10%	90.38	7.91	1.28	0.43

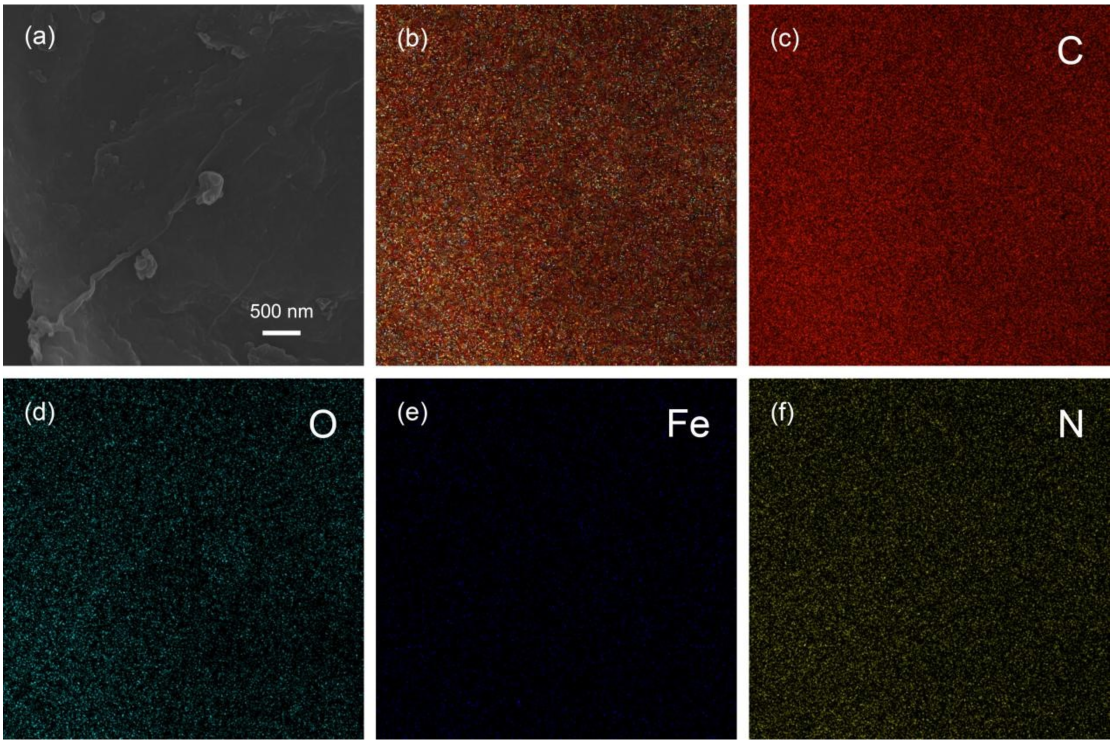

Figure S1. EDS mapping of the APC-Fe-10%

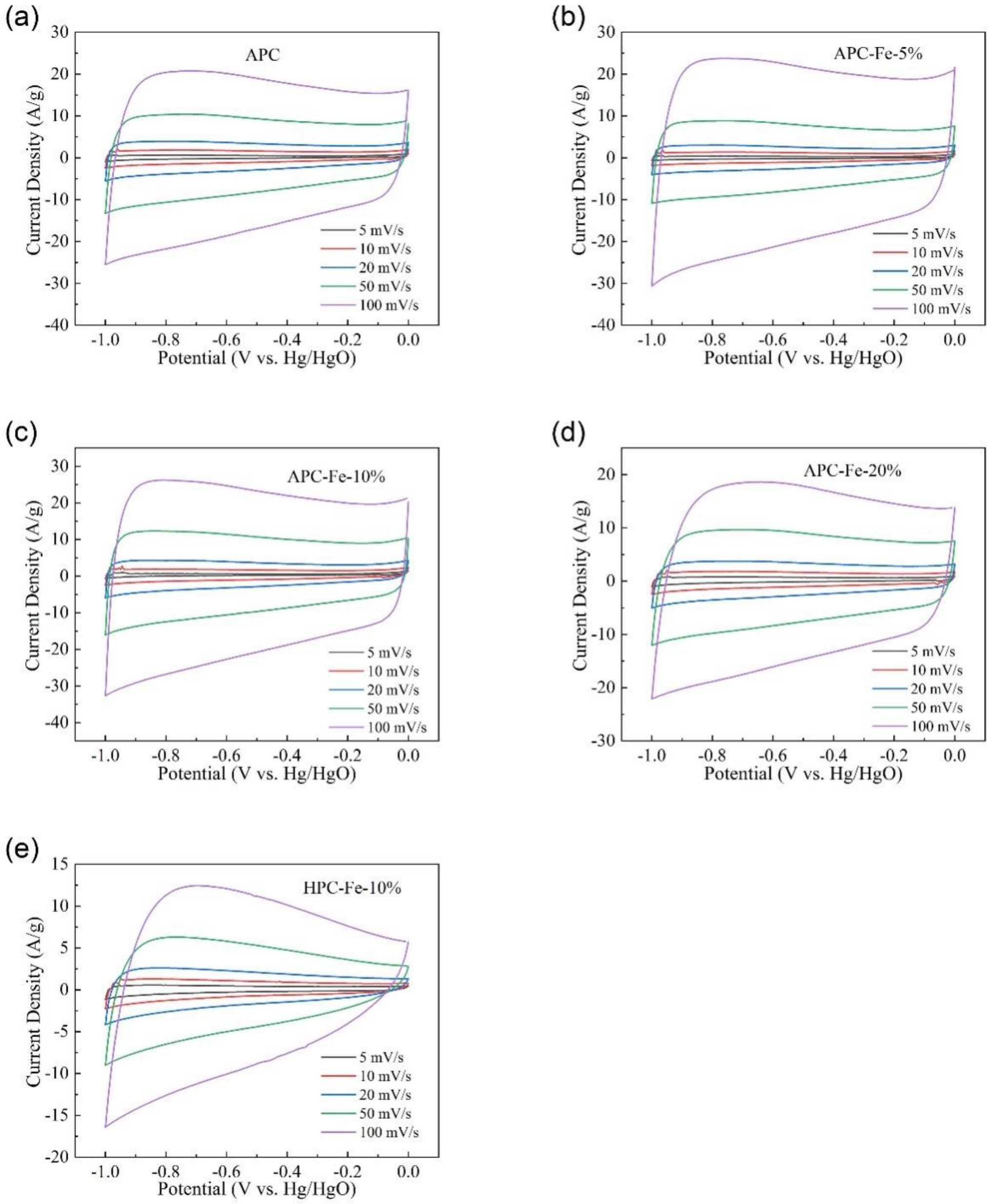

Figure S2. CV curves of the five samples measured in the three-electrode system at different scan rates. (a) APC, (b) APC-Fe-5%, (c) APC-Fe-10%, (d) APC-Fe-20% and (e) HPC-Fe-10%.

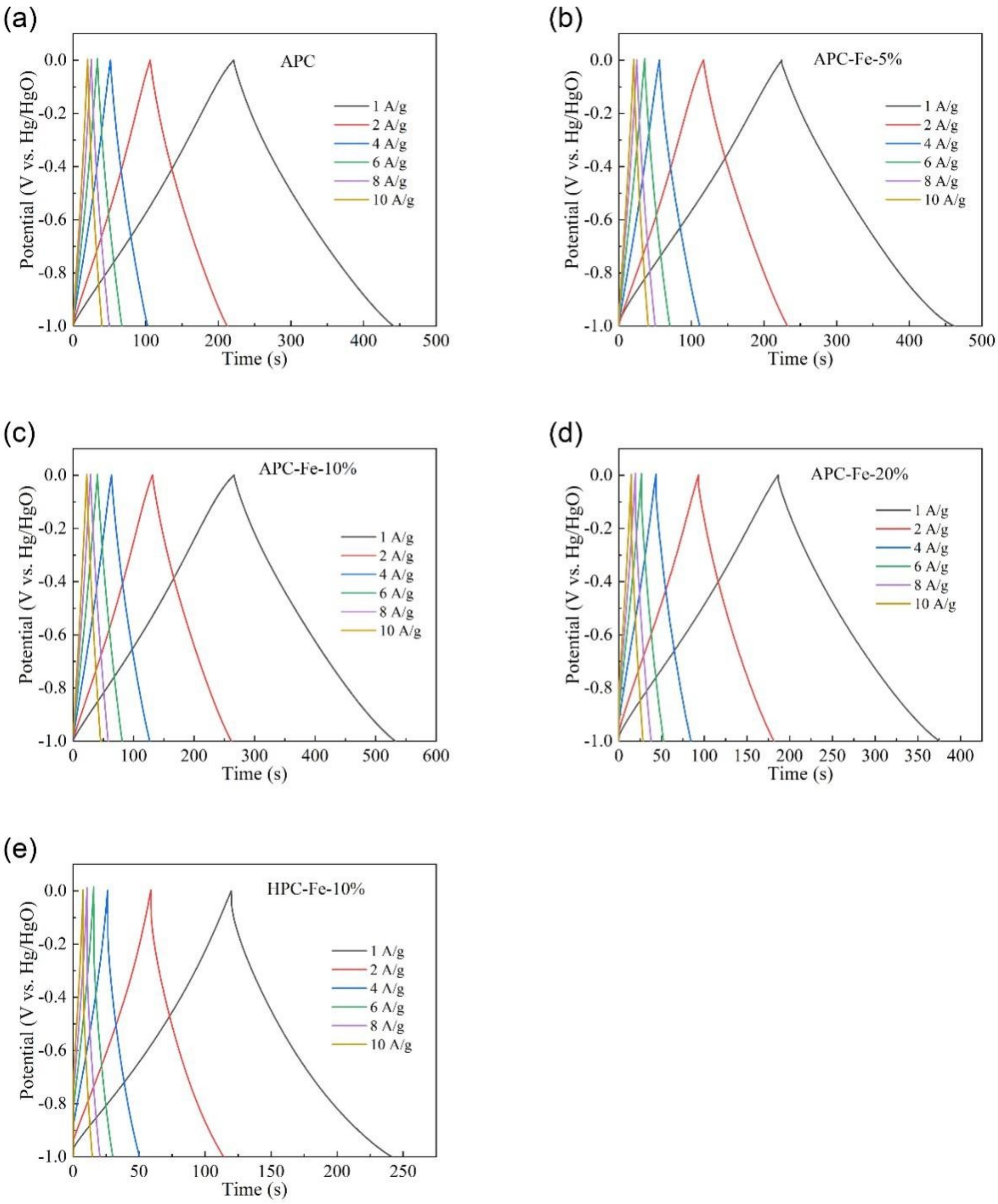

Figure S3. GCD curves of the five samples measured in the three-electrode system at different current densities. (a) APC, (b) APC-Fe-5%, (c) APC-Fe-10%, (d) APC-Fe-20% and (e) HPC-Fe-10%.

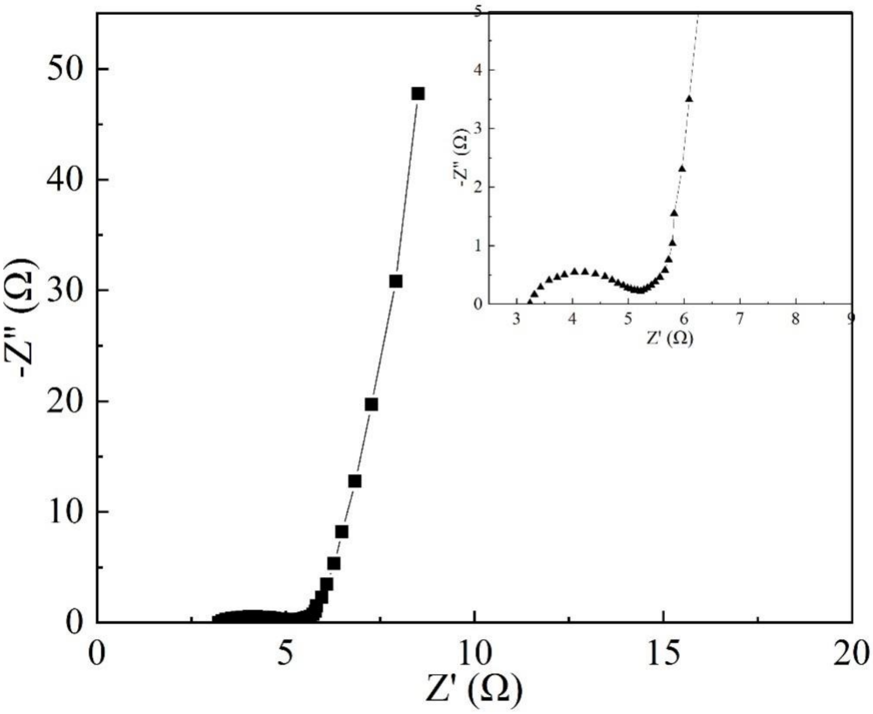

Figure S4. EIS diagram of the APC-Fe-10%-based symmetric device in 1 M Na_2SO_4.

Table S3 Comparison of reported porous carbons derived from biomass for SC.

Raw materials	conditions	Activator	Specific Capacitance (F/g)	Current density (A/g)	Electrolyte	Reference
Durian shell	HTC + H_2O_2	$(NH_4)_2HPO_4$	184	0.5	1M H_2SO_4	1
Cornstalk	HTC	KOH	133.32	1.0	6M KOH	2
zinc gluconate		KOH	172	0.5	6M KOH	3
Eggshell membranes		Air	297	1.0	1M KOH	4
zinc gluconate	$CaCO_3$		137	0.5	6M KOH	5
Bamboo shavings	HTC + $FeCl_3$	KOH	378	0.5	6M KOH	6
zinc gluconate	NH_4Cl		221	1	6M KOH	7
wood/phenolic resin composites		KOH	8169 mF / cm	1 mA / cm	3M KOH	8
Sunflower stalk	HTC	KOH	365	1.0	6M KOH	9
Rice straw	HTC	$KHCO_3$	219	1.0	6M KOH	10
	HTC	$KHCO_3$ + melamine	317	1.0	6M KOH	10
Bamboo	HTC + $Fe_2(SO_4)_3$	$KHCO_3$	467	0.5	6M KOH	11
Pollen/ graphene	NH_4Cl		420	1	6M KOH	12
Hazelnut shell	HTC	$Mg(CH_3COO)_2 \cdot 4H_2O$	323.2	1.0	1M H_2SO_4	13
Cassava rhizome	HTC + HCl	$ZnCl_2$ + melamine	192.5	0.1	1M H_2SO_4	14
Polyimide/ Cellulose			300	1	6M KOH	15
Corn stalk	HTC + LiCl, $ZnCl_2$	$K_2C_2O_4$ and $CaCO_3$	375	0.5	1M H_2SO_4	16
Broussonetia papyrifera		KOH	320	0.5	6M KOH	17
Wheat straw	HTC	KOH	318	1.0	6M KOH	18
Jackfruit inner skin	HTC + $Fe_2(SO_4)_3$	$KHCO_3$	267	1.0	6M KOH	This work

1. Kangyao Wang, Ziyue Zhang, Qimeng Sun, Peng Wang and Yueming Li. Durian shell-derived N, O, P-doped activated porous carbon materials and their electrochemical performance in supercapacitor. J. Mater. Sci., 2020, 55, 10142–10154.

2. Jixiu Jia, Zonglu Yao, Lixin Zhao, Teng Xie, Yuxuan Sun, Liwei Tian, Lili Huo, Zhidan Liu, Functionalization of supercapacitors electrodes oriented hydrochar from cornstalk: A new vision via biomass fraction, Biomass Bioenergy, 2023, 175, 106858.

3. Gaigai Duan, Junlei Xiao, Lian Chen, Chunmei Zhang, Shaoju Jian, Shuijian He, Feng Wang. Zinc gluconate derived porous carbon electrode assisted high rate and long cycle performance supercapacitor. Journal of Energy Storage. 2023, 67, 107559.

4. Wang, Huanlei, Zhi Li, and David Mitlin. "Tailoring biomass‐derived carbon nanoarchitectures for high‐performance supercapacitors." ChemElectroChem, 2014, 1(2) 332-337.

5. Duan, Gaigai, Junlei Xiao, Zhiwei Tian, Shaohua Jiang, Chunmei Zhang, Kunming Liu, and Feng Wang. "Nano-$CaCO_3$ templated porous carbon enable high-rate and ultralong cycle performance supercapacitor." Journal of Energy Storage. 2024, 78, 109934.

6. Guofeng Qiu, Yang Guo, Jie Xu, Wenke Jia, Sixi Guo, Hongguan Wang, Fanhui Guo, Jianjun Wu, Hierarchical porous carbon derived from recycled bamboo waste as supercapacitors electrodes based on $FeCl_3$-catalyzed hydrothermal pretreatment: Pore regulation and high-performance analysis. Int. J. Energy Res., 2022, 46, 22971–22990.

7. Tian, Zhiwei, Zhangzhao Weng, Junlei Xiao, Feng Wang, Chunmei Zhang, and Shaohua Jiang. "Hierarchically porous carbon nanosheets from one-step carbonization of zinc gluconate for high-performance supercapacitors." International Journal of Molecular Sciences. 2023, 24(18), 14156.

8. Zhiwei Tian, Xiuling Yang, Gaigai Duan, Shuijian He, Xiaoshuai Han, Haoqi Yang, Shaoju Jian, Jiapeng Hu, Yong Huang, Jingquan Han, Shaohua Jiang. "Phenolic resin filled wood-derived hierarchically porous carbon monolith for high areal capacitance supercapacitors." Industrial Crops and Products. 2024, 218, 118990.

9. Xiaodong Wang, Sining Yun, Wen Fang, Chen Zhang, Xu Liang, Zhibin Lei, and Zonghuai Liu, Layer-Stacking Activated Carbon Derived from Sunflower Stalk as Electrode Materials for High-Performance Supercapacitors, ACS Sustainable Chemistry & Engineering, 2018, 6 (9), 11397-11407.

10. Zenghua Xu, Ximing Zhang, Yue Liang, Hongjian Lin, Shen Zhang, Jianglong Liu, Caidi Jin, Ungyong Choe, and Kuichuan Sheng, Green Synthesis of Nitrogen-doped Porous Carbon Derived from Rice Straw for High-performance Supercapacitor Application, Energy Fuels, 2020, 34, 8966–8976.

11. Zenghua Xu, Ximing Zhang, Kai Li, Hongjian Lin, Xiangqun Qian, and Kuichuan Sheng, Green Synthesis of Fe-Decorated Carbon Sphere/Nanosheet Derived from Bamboo for High-Performance Supercapacitor Application, Energy & Fuels 2021 35 (1), 827-838.

12. Cao, Lihua, Huiling Li, Xiaolin Liu, Shuwu Liu, Lin Zhang, Wenhui Xu, Haoqi Yang Shuijian He, Yan Zhao, Shaohua Jiang. "Nitrogen, sulfur co-doped hierarchical carbon encapsulated in graphene with “sphere-in-layer” interconnection for high-performance supercapacitor." Journal of Colloid and Interface Science, 2021, 599, 443-452.

13. Neriman Sinan, Ece Unur, Hydrothermal conversion of lignocellulosic biomass into high-value energy storage materials, Journal of Energy Chemistry, 2017, 26(4), 783–789.

14. Gittisak Phachwisoot, Kamonwat Nakason, Chalathorn Chanthad, Pongtanawat Khemthong, Wasawat Kraithong, Saran Youngjan, and Bunyarit Panyapinyopol, Sequential Production of Levulinic Acid and Supercapacitor Electrode Materials from Cassava Rhizome through an Integrated Biorefinery Process, ACS Sustainable Chemistry & Engineering, 2021, 9 (23), 7824-7836.

15. Li, Huiling, Lihua Cao, Huijun Zhang, Zhiwei Tian, Qian Zhang, Feng Yang, Haoqi Yang, Shuijian He, and Shaohua Jiang. "Intertwined carbon networks derived from Polyimide/Cellulose composite as porous electrode for symmetrical supercapacitor." Journal of Colloid and Interface Science, 2022, 609, 179-187.

16. Xue-Qin Ma, Bo Zhang, Zhi-Xiang Xu, Yi Tan, Bin Li, Yong-Cai Zhang, Guo-Song Ni, Wei-You Zhou, Rafael Luque, Hui-Yan Zhang, N-rich and O-poor doped carbon prepared via facile ammonium nitrate assisted hydrothermal carbonization for robust supercapacitors, Journal of Cleaner Production, 2022, 373. 133903.

17. Wei, Tongye, Yong Gao, and Huaming Li. "Large scale production of biomass-derived nitrogen-doped porous carbon materials for supercapacitors." Electrochimica Acta,2015, 169, 186-194.

18. Chenjun He, Mei Huang, Li Zhao, Yongjia Lei, Jinsong He, Dong Tian, Yongmei Zeng, Fei

Shen, Jianmei Zou, Enhanced electrochemical performance of porous carbon from wheat straw as remolded by hydrothermal processing, Science of The Total Environment, 2022, 842, 156905.