Supplementary Information

KCl-assisted activation: Moringa oleifera branch-derived porous carbon for high performance supercapacitor

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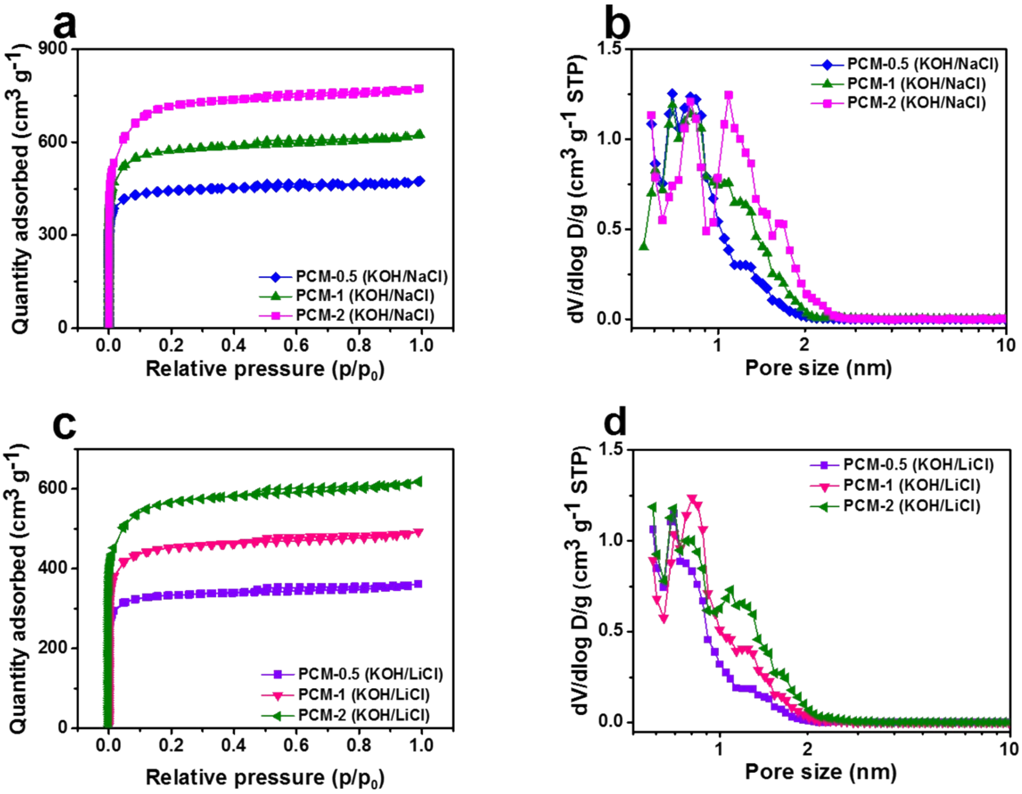


Figure S1. (a) N_2 adsorption-desorption isotherms, (b) DFT pore size distribution curves of PCM-0.5 (KOH/NaCl), PCM-1 (KOH/NaCl) and PCM-2 (KOH/NaCl). (c) N_2 adsorption-desorption isotherms, (d) DFT pore size distribution curves of PCM-0.5 (KOH/LiCl), PCM-1 (KOH/LiCl) and PCM-2 (KOH/LiCl).

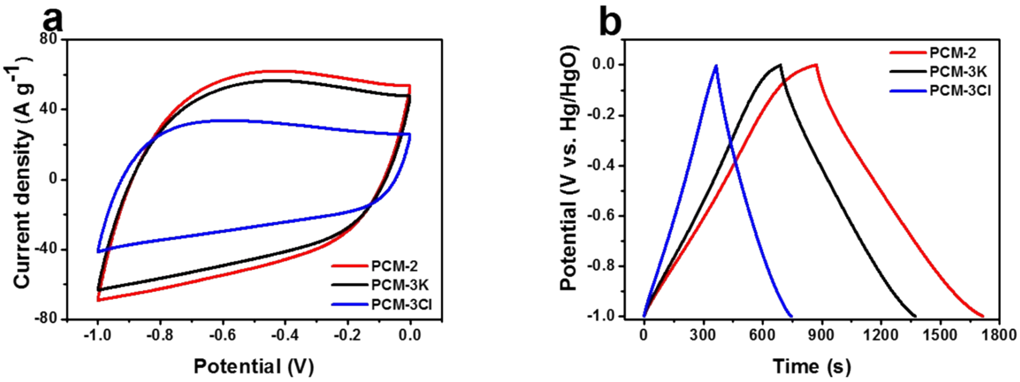


Figure S2. Comparison of (a) CV curves at 200 mV s^{-1} and (b) GCD curves at 0.5 A g^{-1} for PCM-2, PCM-3K and PCM-3Cl in a three-electrode system by using 6.0 M KOH aqueous solution as the electrolyte.

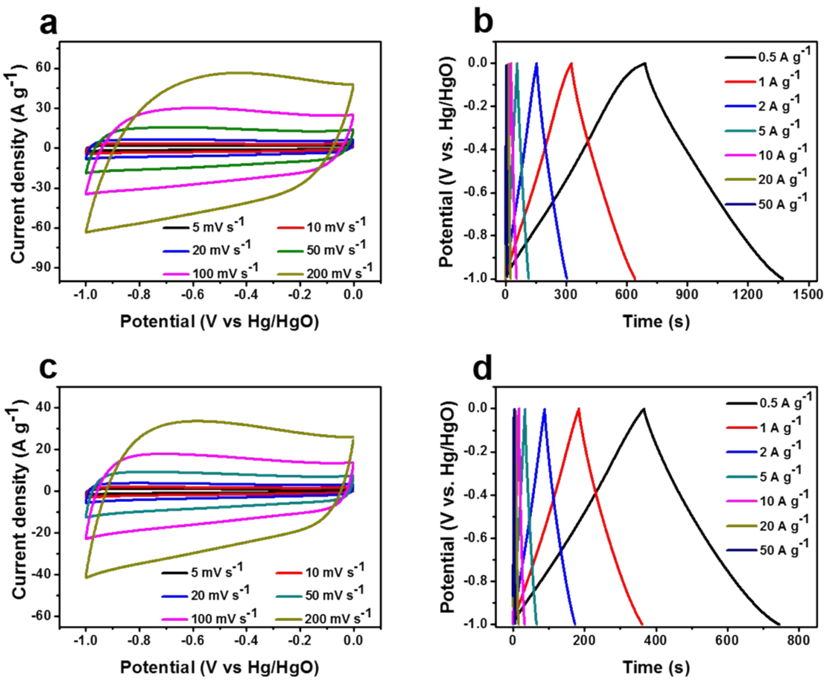


Figure S3. CV and GCD curves of (a, b) PCM-3K and (c, d) PCM-3Cl in a three-electrode system by using 6.0 M KOH aqueous solution as the electrolyte.

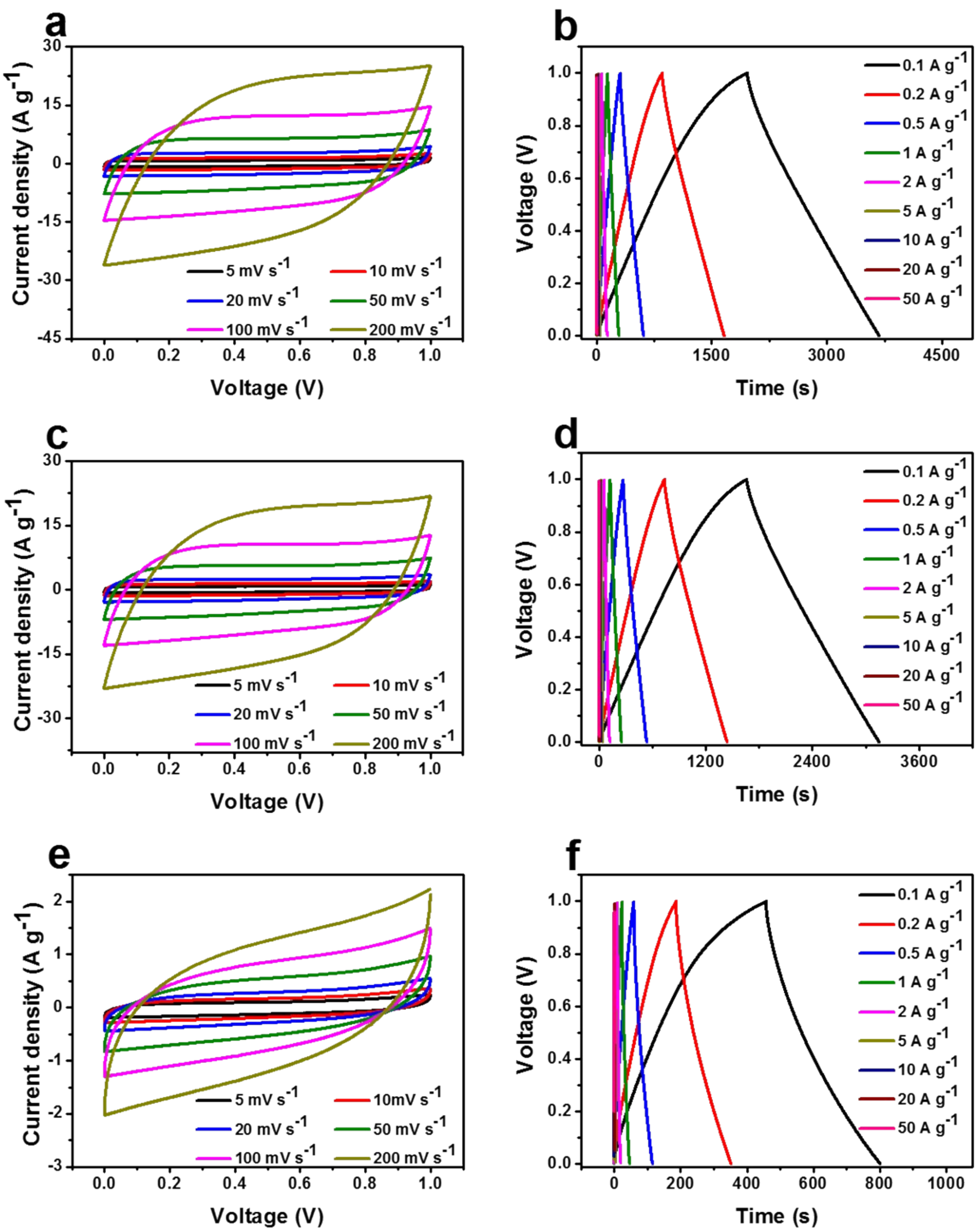


Figure S4. CV and GCD curves of (a, b) PCM-2, (c, d) PCM-3K and (e, f) PCM-3Cl coin-type symmetrical supercapacitors by using 6 M KOH aqueous solution as electrolyte.

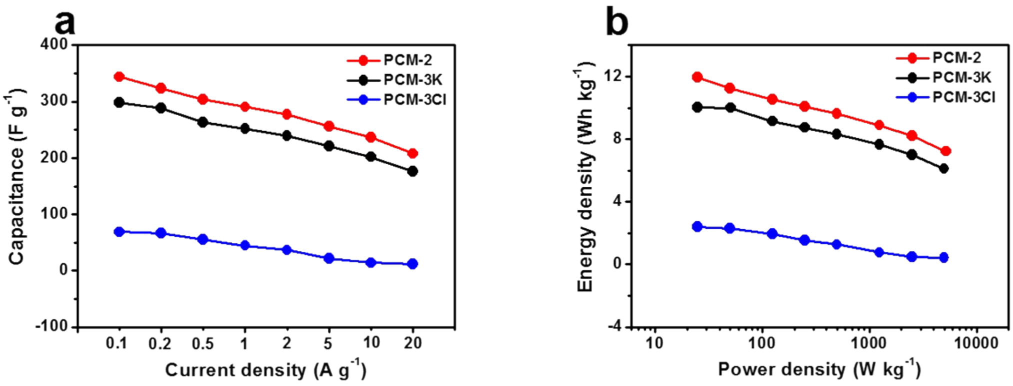


Figure S5. (a) Capacitance comparison of PCM-2, PCM-3K and PCM-3Cl at various current densities in a coin-type supercapacitor and (b) Ragone plots of sample in coin-type supercapacitors by using 6.0 M KOH aqueous solution as the electrolyte.

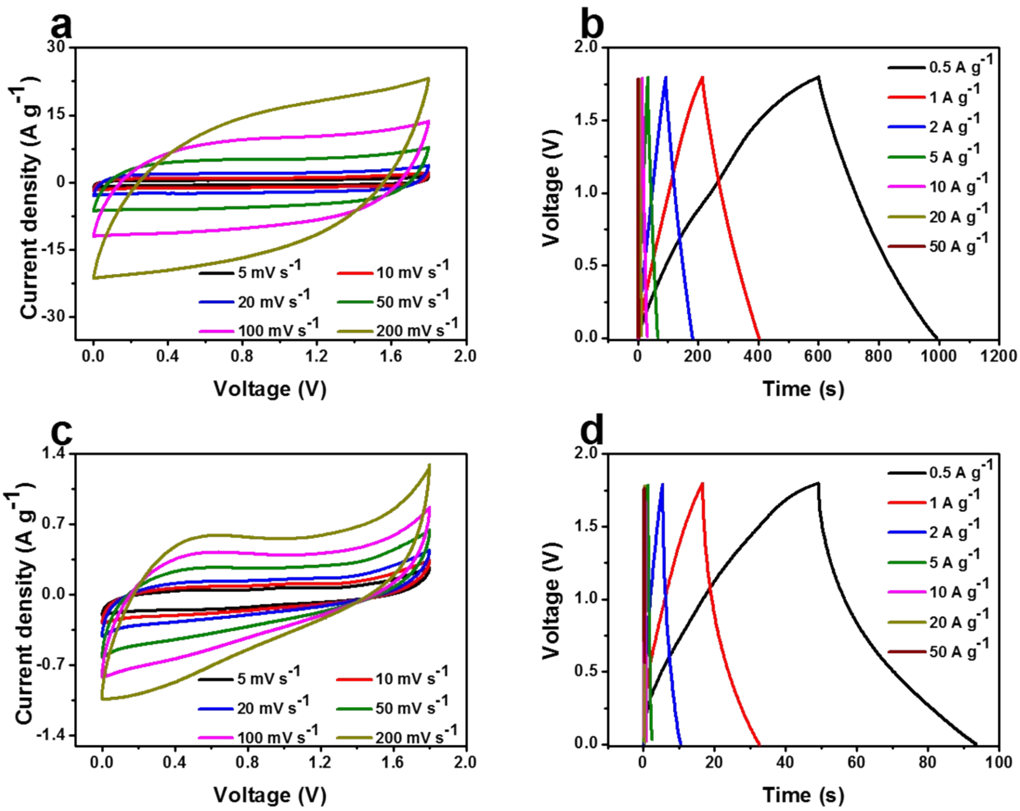


Figure S6. CV and GCD curves of (a, b) PCM-3K and (c, d) PCM-3Cl coin-type symmetrical supercapacitors by using 1.0 M Na_2SO_4 aqueous solution as electrolyte.

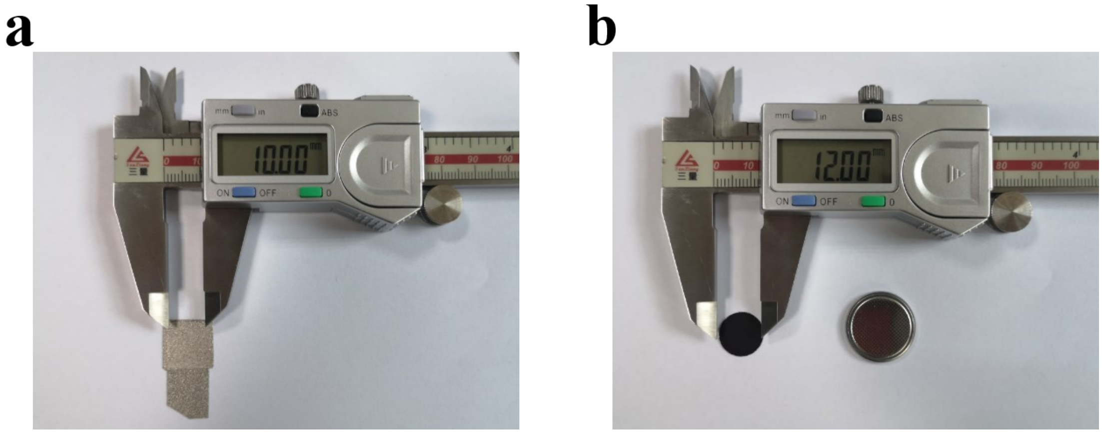


Figure S7. (a) The size dimension of PCMs electrode for the three-electrode system (1x1 cm^2), (b) The size dimension of the PCMs electrode for the two-electrode symmetrical supercapacitors (0.36π cm^2).

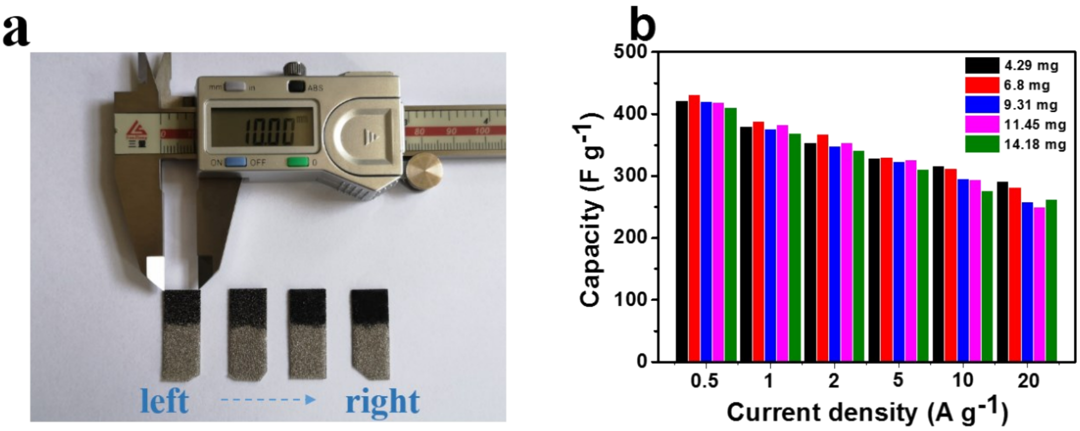


Figure S8. (a) The PCM-2-based electrodes loaded with different masses (the loading masses from left to right are 6.8, 9.31, 11.45 and 14.18 mg cm^{-2} (including active materials, carbon black**,** PTFE and the mass ratio is 8:1:1), respectively. (b) The gravimetric capacitance of PCM-2-base electrodes loaded with different masses.

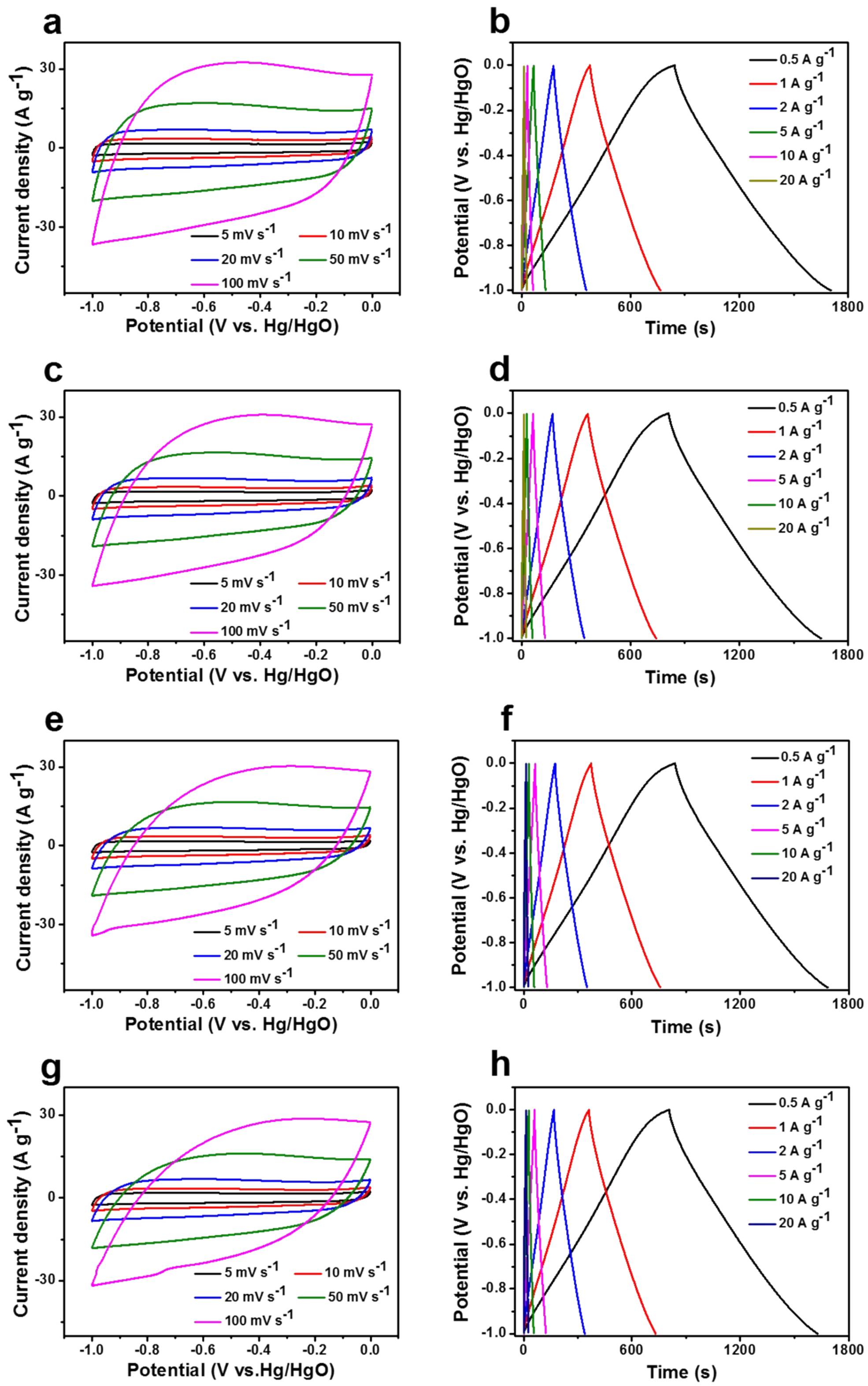


Figure S9. CV and GCD curves of PCM-2 electrodes loaded with different masses in a three-electrode system by using 6.0 M KOH aqueous solution as the electrolyte. (a, b) 6.8, (c, d) 9.31, (e, f) 11.45 and (g, h) 14.18 mg cm^{-2}.

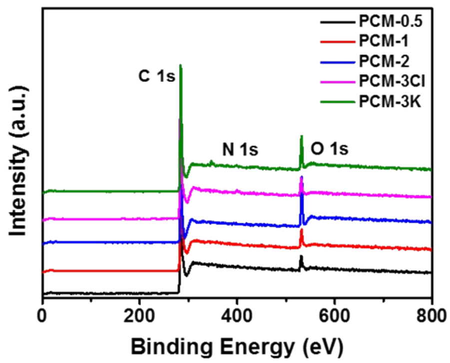
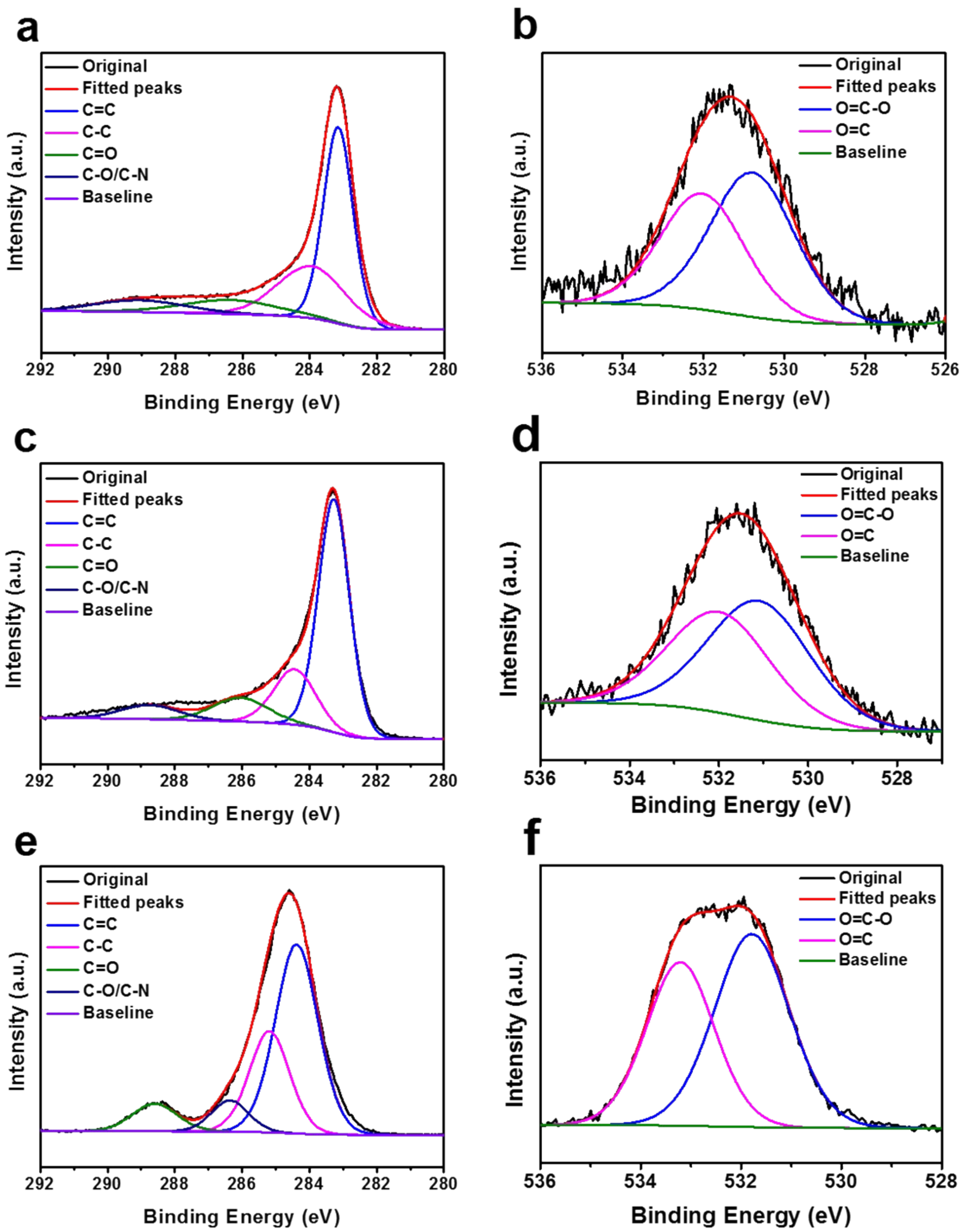


Figure S10. XPS spectra of the as-prepared PCM-0.5, PCM-1, PCM-2, PCM-3Cl and PCM-3K.



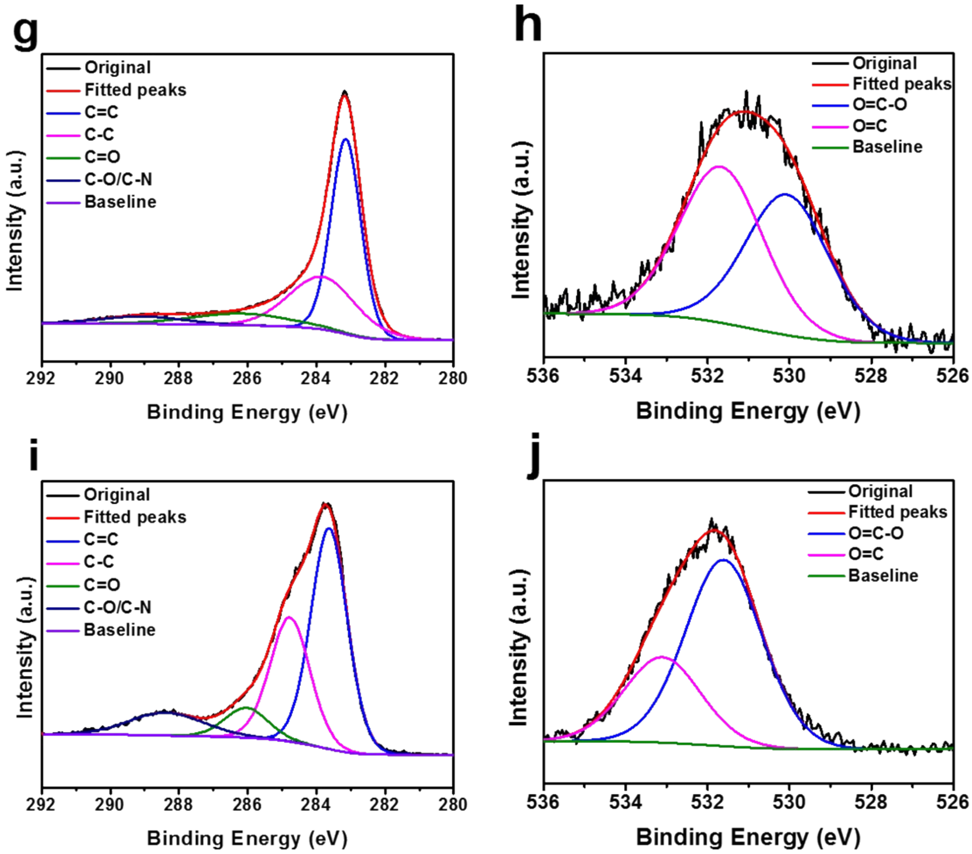


Figure S11. High-resolution C 1s and O 1s XPS spectra of (a, b) PCM-0.5, (c, d) PCM-1, (e, f) PCM-2, (g, h) PCM-3Cl and (i, j) PCM-3K.

Table S1. Summary of textural characteristics of as-prepared samples (KOH/KCl).

Sample	$^{a}S_{BET}$ (m^2 g^{-1})	$^{b}S_{mic}$ (m^2 g^{-1})	$^{c}V_t$ (cm^3 g^{-1})	$^{d}V_{mic}$ (cm^3 g^{-1})	^{e}Biomass yields (%)
PCM-3Cl	927	861	0.38	0.33	17.5
PCM-0.5	2314	2166	0.94	0.84	15.6
PCM-1	2703	2546	1.15	1.03	14.6
PCM-2	3470	2786	1.69	1.16	12.5
PCM-3K	3389	2481	1.67	1.03	9.8

Table S2. Summary of textural characteristics of as-prepared samples (KOH/NaCl).

Sample	$^{a}S_{BET}$ (m^2 g^{-1})	$^{b}S_{mic}$ (m^2 g^{-1})	$^{c}V_t$ (cm^3 g^{-1})	$^{d}V_{mic}$ (cm^3 g^{-1})
PCM-0.5 (KOH/NaCl)	1759	1639	0.73	0.63
PCM-1 (KOH/NaCl)	2219	2069	0.95	0.81
PCM-2 (KOH/NaCl)	2697	2477	1.19	1.0

Table S3. Summary of textural characteristics of as-prepared samples (KOH/LiCl).

Sample	$^{a}S_{BET}$ (m^2 g^{-1})	$^{b}S_{mic}$ (m^2 g^{-1})	$^{c}V_t$ (cm^3 g^{-1})	$^{d}V_{mic}$ (cm^3 g^{-1})
PCM-0.5 (KOH/LiCl)	1325	1228	0.55	0.47
PCM-1 (KOH/LiCl)	1767	1641	0.75	0.64
PCM-2 (KOH/LiCl)	2169	1741	0.94	0.69

(a) Specific surface area.

(b) Micropore surface area.

(c) Total pore volume.

(d) Micropore volume.

(e) The yield of the porous carbon based on raw materials.

Table S4. The specific surface areas and preparation conditions of porous carbon derived from different precursors reported in the literatures.

Carbon precursors	S_{BET} (m^2 g^{-1})	S_{mico} (m^2 g^{-1})	T (^oC)	Activation agent	Ref.
Soybean milk powder	1208	987	700	$KOH/CaCO_3$	[1]
Mung bean husks	1278	1057	700	KOH	[2]
Tannic acid	1570	1333	800	$NaCl/ZnCl_2$	[3]
Ripe plane tree fluff	1416	995	800	$KOH/FeNO_3$	[4]
Petroleum asphalt	2227	1741	900	KOH/NaCl/KCl	[5]
Rice straw	2646	1416	800	KOH	[6]
Wild jujube pit powder	2438	2170	800	KOH	[7]
Eulaliopsis binata	2273	1045	850	KOH	[8]
Puffed rice	3326	2193	850	KOH	[9]
Miscellaneous wood fibers	1807	1743.5	800	KOH	[10]
Wax gourd	2544	1747	800	KOH	[11]
Camellia oleifera	1726	858	800	KOH	[12]
Rhus typhina	2676	2354	800	KOH	[13]
Stachyurus Chinensis Franch	1994	647.6	800	KOH	[14]
Corncob sponge	1909	1209	850	KOH	[15]
Fallen leaves	1409	791	700	KOH/K_2CO_3	[16]
D- (+)-glucose	1500	1440	700	$KOH/ZnCl_2$	[17]
Moringa oleifera branch	**3470**	**2786**	**800**	**KOH/KCl**	**This work**

Table S5. The detailed element content of C, N, and O.

Sample	C_{total} (%)	N_{total} (%)	O_{total} (%)
PCM-0.5	94.1	0.85	5.05
PCM-1	92.94	1.12	5.94
PCM-2	84.18	0.85	14.97
PCM-3Cl	92.43	2.03	5.54
PCM-3K	88.67	1.37	9.97

Table S6. Electrochemical performance of Moringa oleifera branch-derived porous carbon in three-electrode system (6 mol L^{-1} KOH and current density of 0.5 A g^{-1}).

Sample	Active material (mg)	Area (cm^2)	Gravimetric capacitance (F g-1)	Areal capacitance (mF cm^{-2})
PCM-2	3.43	1	421	1444
PCM-3K	3.48	1	340	1183
PCM-3Cl	3.42	1	189	645

Table S7. Electrochemical performance of Moringa oleifera branch-derived porous carbon in two-electrode system (6 mol L^{-1} KOH and current density of 0.1 A g^{-1}).

Sample	Active material (mg)	Area (cm^2)	Gravimetric capacitance (F g-1)	Areal capacitance (mF cm^{-2})
PCM-2	3.45//3.47	0.36π	343.8	1052
PCM-3K	3.04//3.11	0.36π	297.8	808

Table S8. Electrochemical performance of Moringa oleifera branch-derived porous carbon in two-electrode system (1 mol L^{-1} Na_2SO_4 and current density of 0.5 A g^{-1}).

Sample	Active material (mg)	Area (cm^2)	Gravimetric capacitance (F g-1)	Areal capacitance (mF cm^{-2})
PCM-2	3.24//3.29	0.36π	293.7	848
PCM-3K	3.45//3.58	0.36π	195.5	607.9

Table S9. The comparison of electrochemical performance between Moringa oleifera branch and carbon materials electrodes reported in 6 M KOH electrolyte system.

Carbon precursors	Capacitance ($F\ g^{-1}$)		Current density ($A\ g^{-1}$)	Ref.
	Ref	This work		
Reed membranes	353.6	**421**	0.5	[18]
Silicone resin	322	**421**	0.5	[19]
Waste bones	302	**421**	0.5	[20]
Sucrose	302	**380**	1	[21]
Nanoporous graphene	204	**316**	10	[22]
D (+)-glucosamine	388	**421**	0.5	[23]
Rose	208	**421**	0.5	[24]
Bagasse	320	**421**	0.5	[25]
Cotton stalk	282	**421**	0.5	[26]
Polyacrylonitrile	331	**421**	0.5	[27]
Sewage sludge	379	**421**	0.5	[28]
Cigarette butt	330.1	**421**	0.5	[29]
Tobacco rods	286.6	**421**	0.5	[30]
Black locust seed dregs	333	**380**	1	[31]
Celery	245	**421**	0.5	[32]
Perilla frutescens leaves	270	**421**	0.5	[33]
Willow catkins	231	**316**	10	[34]
Moringa oleifera stem	283	**421**	0.5	[35]

Table S10. The comparison of electrochemical performance for representative carbons in 1 M Na_2SO_4 electrolyte system.

Carbon precursors	Capacitance ($F\ g^{-1}$)	Current density ($A\ g^{-1}$)	Ref.
N, S-Doped porous carbon	204	0.5	[36]
1D carbon nanobelts //MnO_2	265	0.2	[37]
3D Porous carbon nanosheet	230	0.5	[38]
Polyacrylonitrile based porous carbon	218	0.5	[39]
Graphene-like porous carbon	255	0.5	[40]
Hierarchical porous carbon	211	0.5	[41]
Three-dimensional porous carbon	179	0.5	[42]
Nitrogen-doped porous carbon	134	1	[43]
Microporous active carbon	138	1	[44]
Honeycomb-like porous carbon	212	0.5	[45]
Hierarchical porous carbon	186	0.5	[46]
Hierarchical porous carbon	191	0.5	[47]
Carbon nanosheets	272	1	[35]
N, O-enriched porous carbons	157	0.2	[48]
Egg-Box-Like porous carbon	181	0.2	[49]
N/O co-doped carbon	328	0.2	[50]
Porous carbon	206	0.5	[51]
PCM-2	**293.7**	**0.5**	**This work**

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