Electronic Supplementary Material (ESI) for RSC Advances.

Supporting information

Graphite-Type Activated Carbon from Coconut Shell: a Natural Source for Eco-friendly Non-volatile Storage Devices

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Table S1 Configurations of the supercapacitors, precursors amount, materials for electrolyte, and current collectors used in this study.

Active materials	Binders			Current collectors	Electrolytes	Separators
Activated carbon (wt%)	PVP[a] (wt%)	PVDF[b] (wt%)	C black[c] (wt%)			
96	4	-	-	FTO[d]	6 M KOH	Filter paper[g]
96	4	-	-	FTO[d]	1.5 M H_2SO_4	Filter paper[g]
85	-	10	5	Ti plates[e],	1.5 M H_2SO_4	Filter paper[g]
85	-	10	5	Expanded graphite	1.5 M H_2SO_4	Filter paper[g]
85	-	10	5	Expanded graphite	Pure MPPyFSI[f]	Filter paper or Polyethylene[h]

Binders: [a]Polyvinylpyrrolidone (PVP) Mw 8000, Alfa Aesar; [b]Polyvinylidene fluoride (PVDF) Alfa Aesar; [c]carbon black, Alfa Aesar; Current collectors: [d]SnO_2:F (FTO), Solaronix; [e]Ti plates, The Nilaco Corporation; Ionic Liquids electrolytes: [f]1-Methyl-1-propy-pyrrolizium bis(fluorosulfonyl)imide (MPPyFSI), IL-120, Dai-ichi kogyo seiyaku co., ltd ; Separators: [g]Watman filter paper; [h]SETELA, polyethylene film Toray Industries Inc.

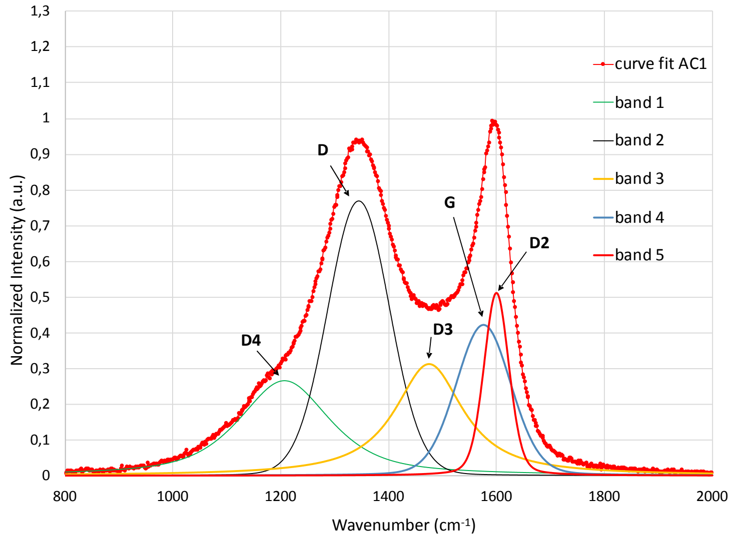

Fig. S1 Normalized Raman spectra and curve fit of activated carbon AC1. A similar fitting band combination was used for all the activated carbon samples.

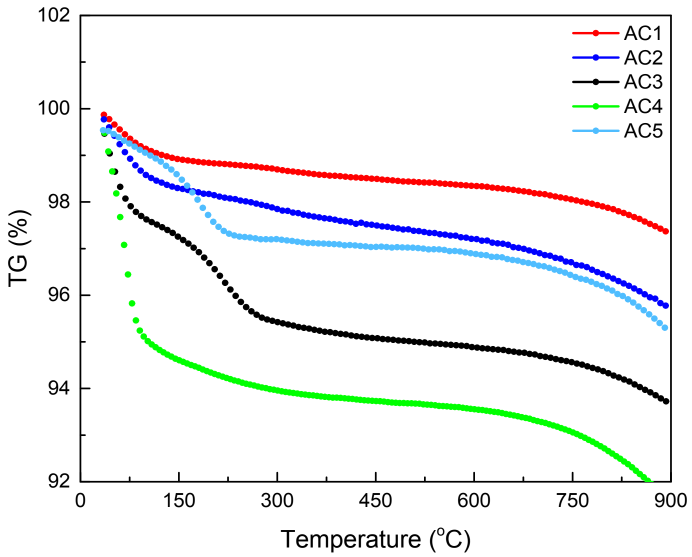

Fig. S2 TG thermograms for the activated carbon AC1-AC5.

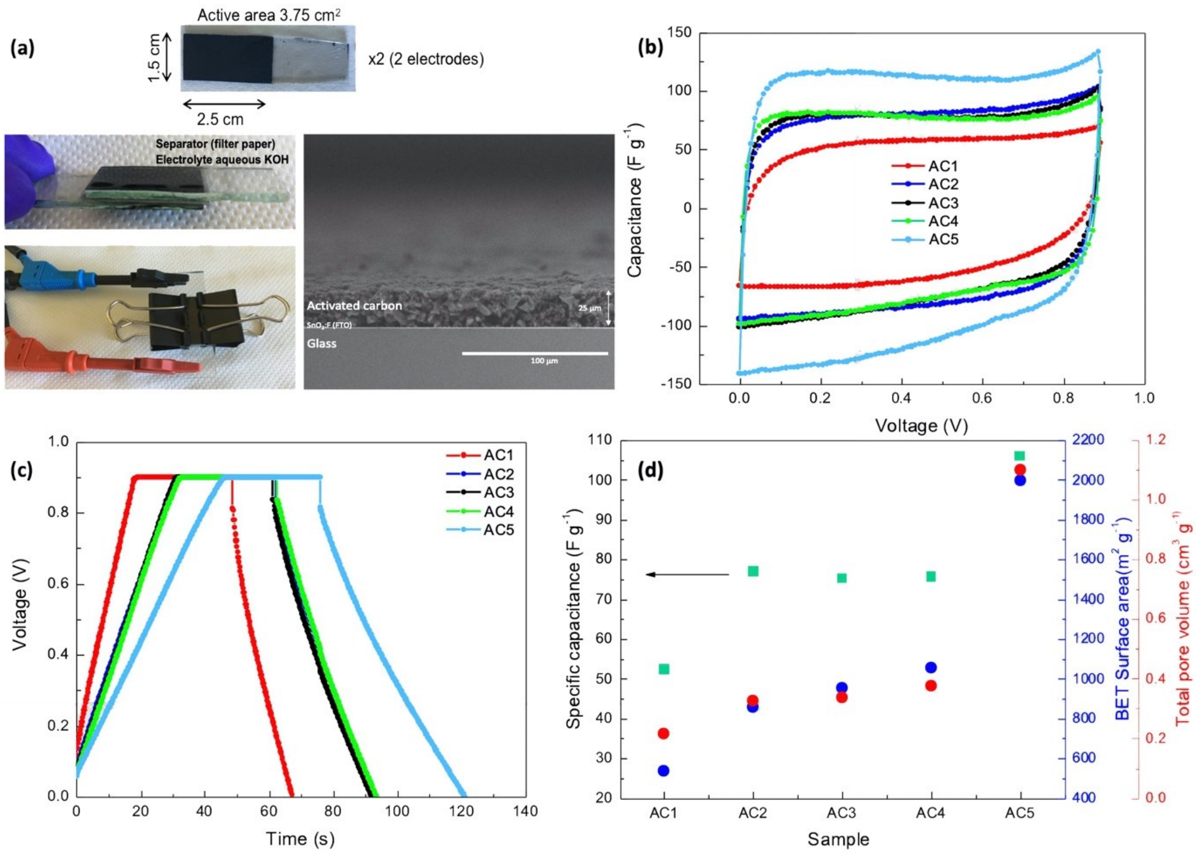

Fig. S3 a) Digital photograph of the supercapacitor based on activated carbon electrodes prepared for this study and the cross-sectional view of the electrode based on activated carbon. b) Cyclic voltammograms measured for the supercapacitors with the FTO:AC-KOH-filter paper-KOH-AC:FTO configuration based on different activated carbon electrodes (AC1-AC5) at 5 mV s^{-1} scan rate. c) Charge-discharge curves for the supercapacitors with the FTO:AC-KOH-filter paper-KOH-AC:FTO configuration based on different activated carbon electrodes (AC1-AC5) at 0.5 A g^{-1} constant current. d) Specific capacitance calculated from the CV curves (green dots) versus BET surface area (blue dots) and total pore volume (red dots).

Table S2 Calculated capacitance values for each activated carbon-based supercapacitor with the FTO:AC-KOH-filter paper-KOH-AC:FTO configuration, CV measured at 5 mV s^{-1} scan rate and galvanostatic CD at specific current 0.5 A g^{-1}.

Samples	S_{BET}, (m^2 g^{-1})	$C_s(C_d)^{CV}$ (F g^{-1})	$C_s(C_d)^{CD}$ (F g^{-1})
AC1	539±16	52.4 (13.1)	42.4 (10.6)
AC2	858±25	76.9 (19.2)	73.0 (18.3)
AC3	952±28	75.2 (18.8)	69.0 (17.3)
AC4	1054±31	75.6 (18.9)	71.2 (17.8)
AC5	1998±58	106 (26.5)	106.0 (26.5)

$C_s(C_d)^{CV}$ specific and device capacitance calculated from CV curves; $C_s(C_d)^{CV}$ specific and device capacitance calculated from CD curves.

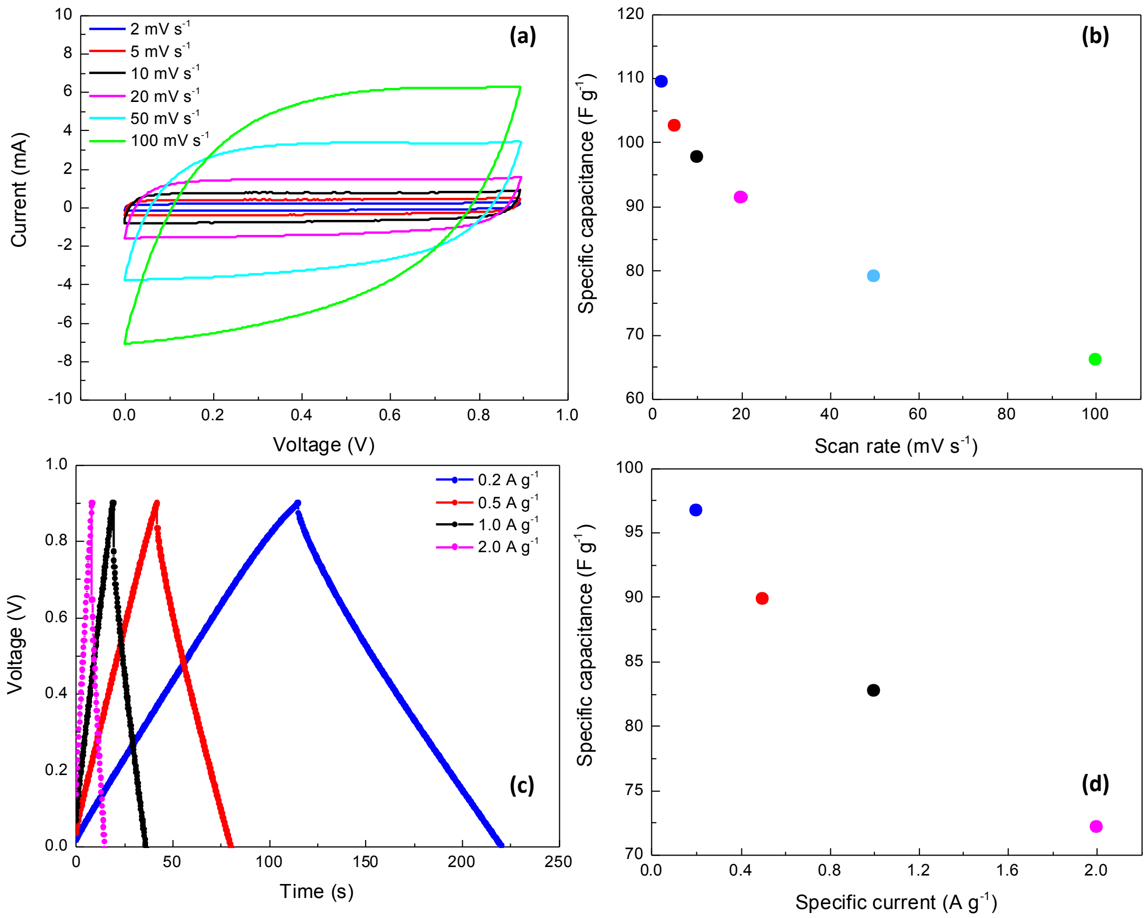

Fig. S4 Electrochemical characterization of the supercapacitor based on AC5 electrodes with configuration FTO:AC5-KOH-filter paper-KOH-AC5:FTO (a) Cyclic voltammograms collected at scan rates between 2 and 100 mV s^{-1}. (b) Specific capacitance calculated from cyclic voltammetry at different scan speeds. (c) Charging-discharging curves at different current densities. (d) Specific capacitance is calculated from charging-discharging curves at different current densities.

Table S3 Calculated capacitance values for each activated carbon-based supercapacitor with the FTO:AC5-KOH-filter paper-KOH-AC5:FTO configuration, CV measured at different scan rates and galvanostatic CD at different specific current.

Scan speed mV s^{-1}	$C_s(C_d)^{CV}$ (F g^{-1})	Specific current A g^{-1}	$C_s(C_d)^{CD}$ (F g^{-1})
2	109.5 (27.4)	0.2	96.7 (24.2)
5	102.7 (25.7)	0.5	89.9 (22.5)
10	97.7 (24.4)	1.0	82.7 (20.7)
20	91.4 (22.8)	2.0	72.2 (18.0)
50	79.1 (19.8)		
100	66.1 (16.5)		

$C_s(C_d)^{CV}$ specific and device capacitance calculated from CV curves; $C_s(C_d)^{CV}$ specific and device capacitance calculated from CD curves.

Table S4 Simulated parameters based on the equivalent circuit shown in Figure 5a.

Impedance parameters	AC1	AC5	Units
S_{BET}^{a}	539±16	1998±58	m^2 g^{-1}
R_1	23	22	Ω
W	16	7.9	Ω $s^{-1/2}$
Q_1	$1.2x10^{-4}$	$32x10^{-6}$	F s^{n-1}
n	0.79	0.84	-
R_a	0.5	9.7	Ω
C_1	16.2 $x10^{-4}$	46.0 $x10^{-4}$	F g^{-1}
C_3	10	22	F g^{-1}
R_3	249	1668	Ω
C at 10^{-2} Hz	44	82	F g^{-1}

*The capacitance (C_1) of the AC1 and AC5 was calculated from the impedance analysis using Q_1, n and R_a, the capacitance C_3 extracted from the impedance fitting and divided by the mass of activated carbon from the electrodes.

Table S5 Calculated capacitance values for activated carbon AC5 based supercapacitor, CV measured at 5 mV s^{-1} scan rate, and galvanostatic CD at specific current 0.5 A g^{-1}.

Supercapacitor configuration	ESR (Ω)	$C_s(C_d)^{CV}$ (F g^{-1})	$C_s(C_d)^{CD}$ (F g^{-1})	E (Wh kg^{-1})	P (W kg^{-1})
1.5 M H_2SO_4:filter paper					
FTO glasses	22.9	105.9 (26.5)	94.48 (23.6)	2.6	224.5
Expanded graphite	0.7	132.3 (33.1)	118.0 (29.5)	3.3	225.1
Titanium plates	7.0	144.9 (36.2)	123.0 (30.8)	3.4	225.4

$C_s(C_d)^{CV}$ specific and device capacitance calculated from CV curves; $C_s(C_d)^{CV}$ specific and device capacitance calculated from CD curves. E and P calculated using device capacitance $(C_d)^{CD}$

Table S6 Calculated capacitance values for activated carbon AC5 based supercapacitor with ionic liquid, CV measured at 5 mV s^{-1} and galvanostatic CD at specific current of 1 A g^{-1}.

Supercapacitor configuration	ESR (Ω)	$C_s(C_d)^{CV}$ (F g^{-1})	$C_s(C_d)^{CD}$ (F g^{-1})	E (Wh kg^{-1})	P (W kg^{-1})
MPPyFSI:filter paper					
FTO glasses	58.3	153.8 (38.5)	153.7 (38.4)	65.4	2123.0
Expanded graphite	22.7	224.5 (56.1)	233.5 (58.4)	99.3	2267.6
Titanium plates	32.7	161.0 (40.3)	170.9 (42.7)	72.7	2037.2
MPPyFSI:polyethylene					
Expanded graphite	4.3	219.4 (54.8)	216.6 (54.1)	92.1	2046.9

$C_s(C_d)^{CV}$ specific and device capacitance calculated from CV curves; $C_s(C_d)^{CV}$ specific and device capacitance calculated from CD curves. E and P calculated using device capacitance $(C_d)^{CD}$.

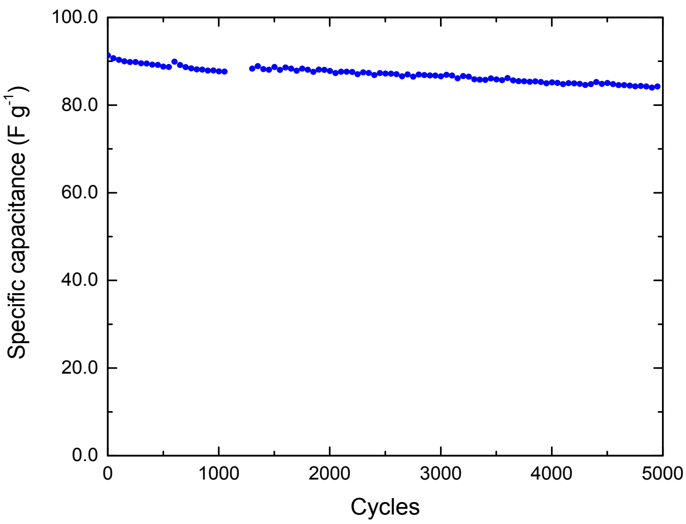

Fig. S5 Stability tests of charging-discharging curves (1 V charging voltage, 1 A g^{-1} discharge current) of sealed supercapacitor, Ti plates as electrodes, AC5 active material, filter paper as separator and ionic liquid MMPyFSI as electrolyte.