Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Bio-inspired high-performance solid-state supercapacitors with electrolyte, separator, binder and electrodes entirely from *kelp*

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Table S1. Property parameters of the commercial activated carbon TF-B520

Density	0.32-0.40 g cm^{-3}
Particle size	5(±1) μm
Ash content	<0.07%
pH value	6.0-7.0
Specific surface area	2000 (±100) m^2 g^{-1}
Pore volume	1.0-1.2 cm^3 g^{-1}
Pore size	2.0-2.2 nm
Carbon content	＞95%
Metal ions from ICP	<1000 ppm

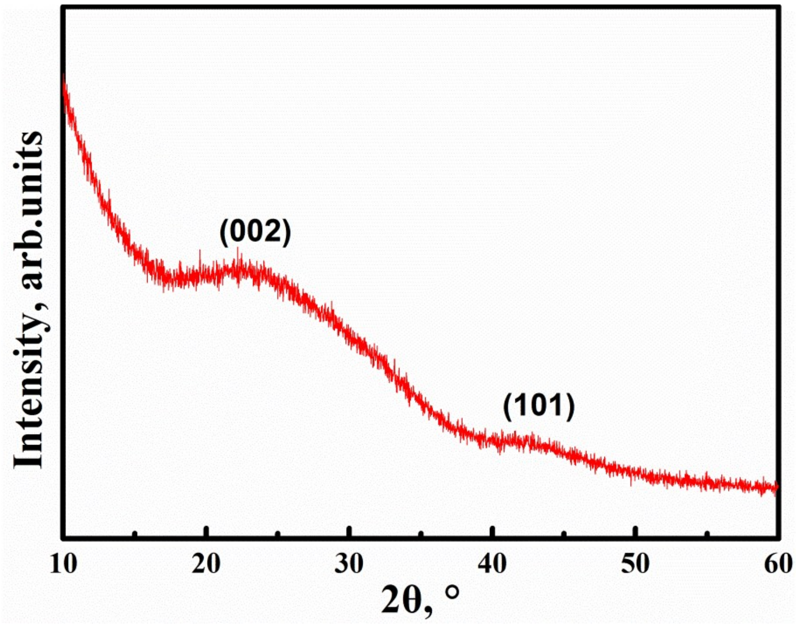

Fig. S1 XRD pattern of the *kelp*-derived activated carbon (KAC).

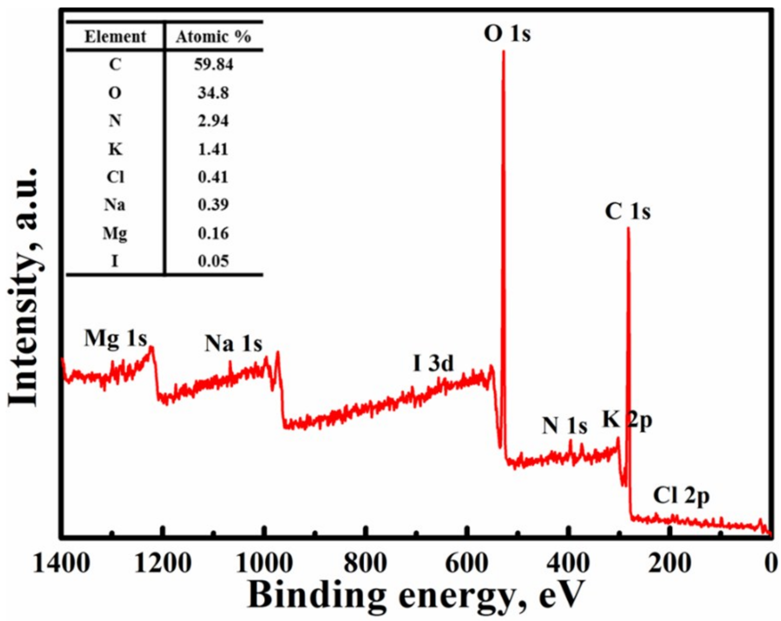

Fig. S2 XPS spectrum with all elements detected in *kelp*, the inset shows the atomic contents of each element.

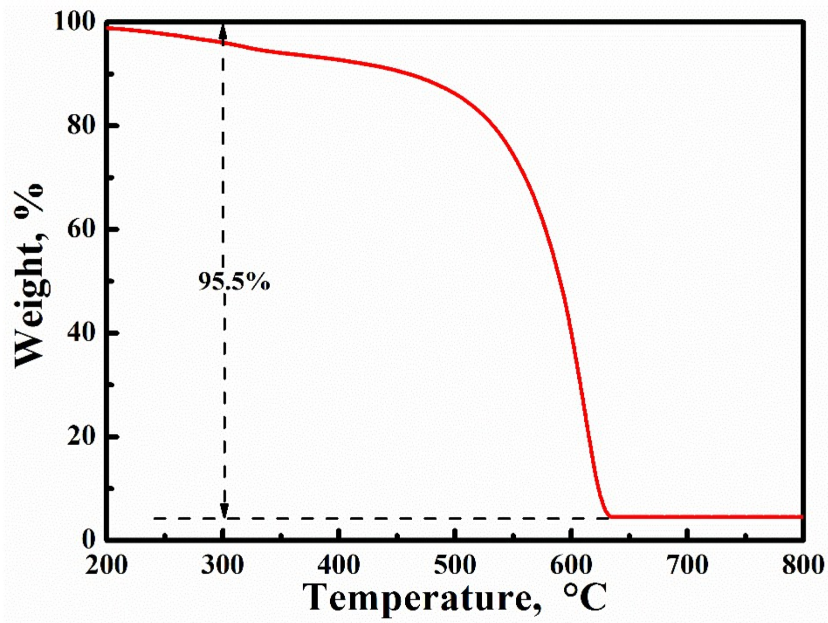

Fig. S3 Thermogravimetric curve of KAC in air.

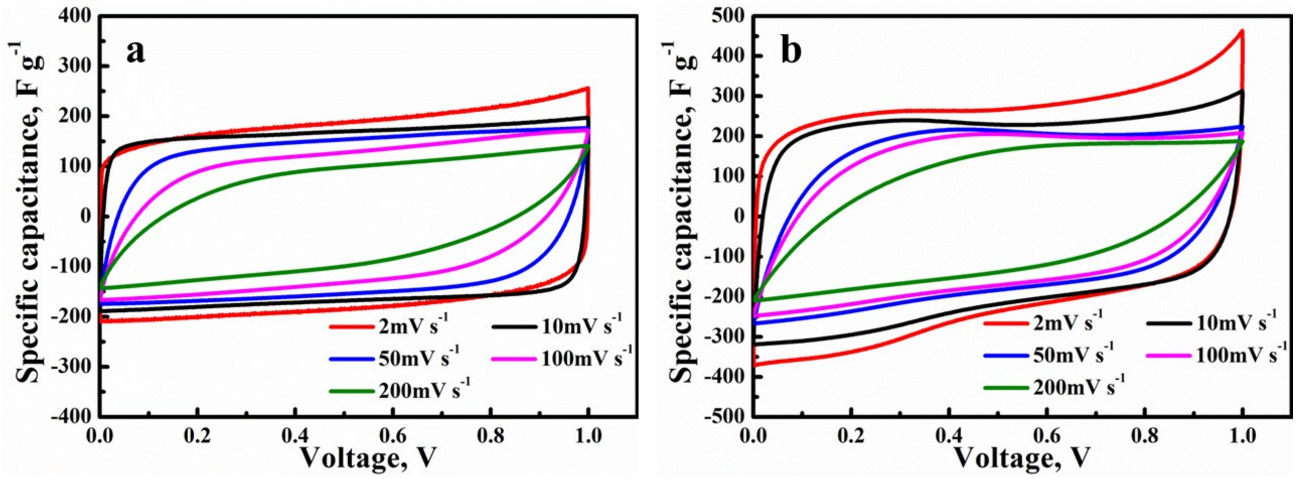

Fig. S4 CV curves of (a) supercapacitor based on commercial activated carbon (TF-B520) electrodes, Na-alginate binder, Na-alginate separator and Na-alginate hydrogel electrolyte, and (b) supercapacitor with KAC electrodes, PTFE binder, commercial polypropylene separator and 1 M H_2SO_4 aqueous electrolyte.

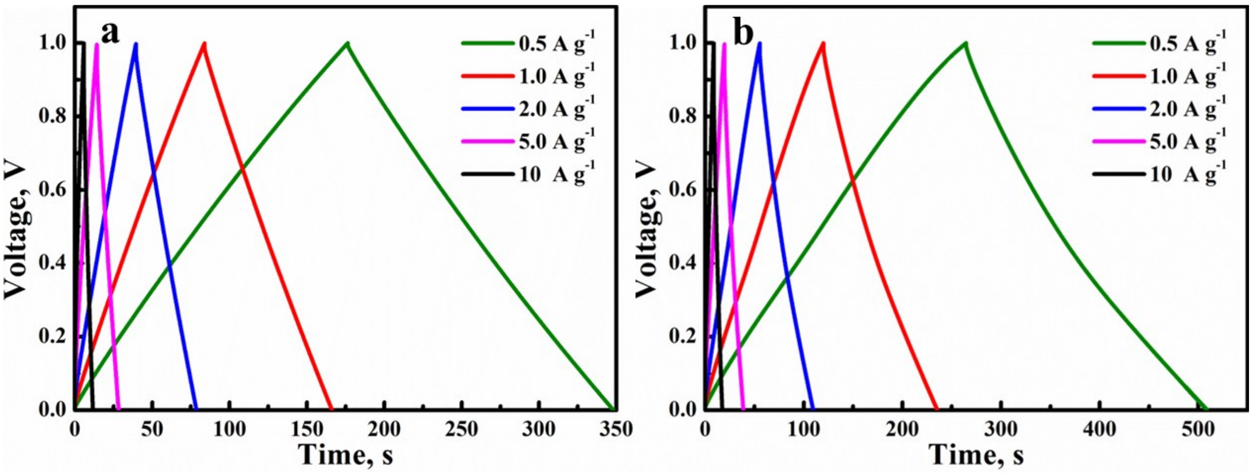

Fig. S5 C-D curves of (a) supercapacitor based on commercial activated carbon (TF-B520) electrodes, Na-alginate binder, Na-alginate separator and Na-alginate hydrogel electrolyte, and (b) supercapacitor with KAC electrodes, PTFE binder, commercial polypropylene separator and 1 M H_2SO_4 aqueous electrolyte.

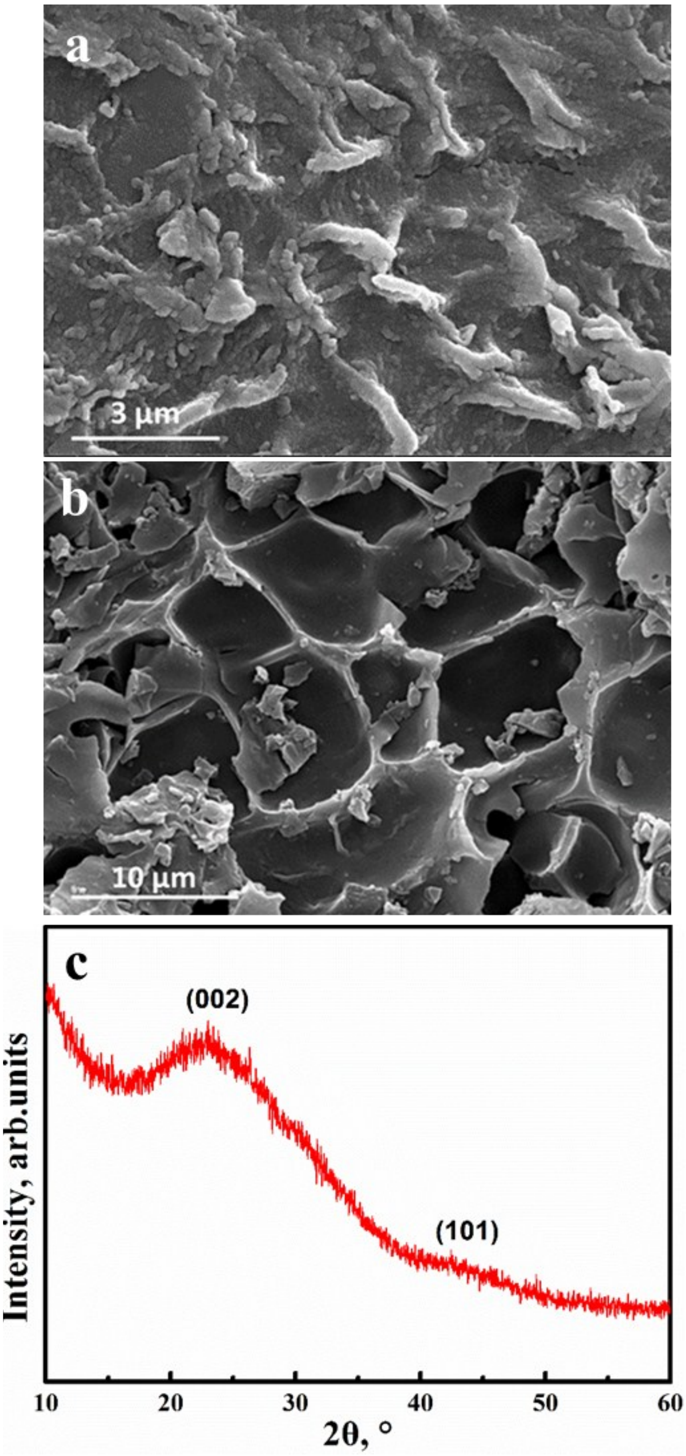

Fig. S6 (a, b) SEM images and (c) XRD pattern of KAC electrode material after charge-discharge cycling tests.

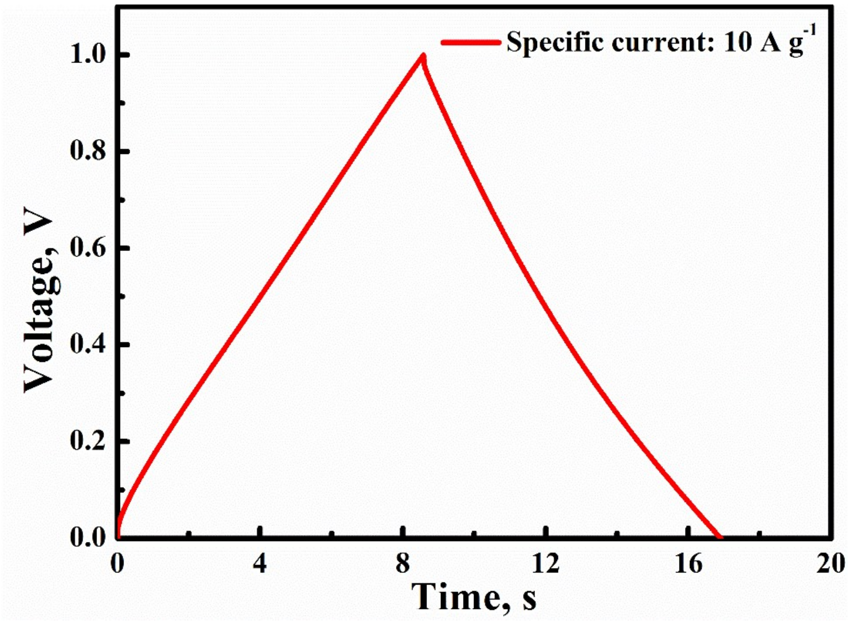

Fig. S7 C-D curve of the "all-*kelp*" solid-state supercapacitor re-tested at 60 °C after 10,000 C-D cycles at 10 A g^{-1}.

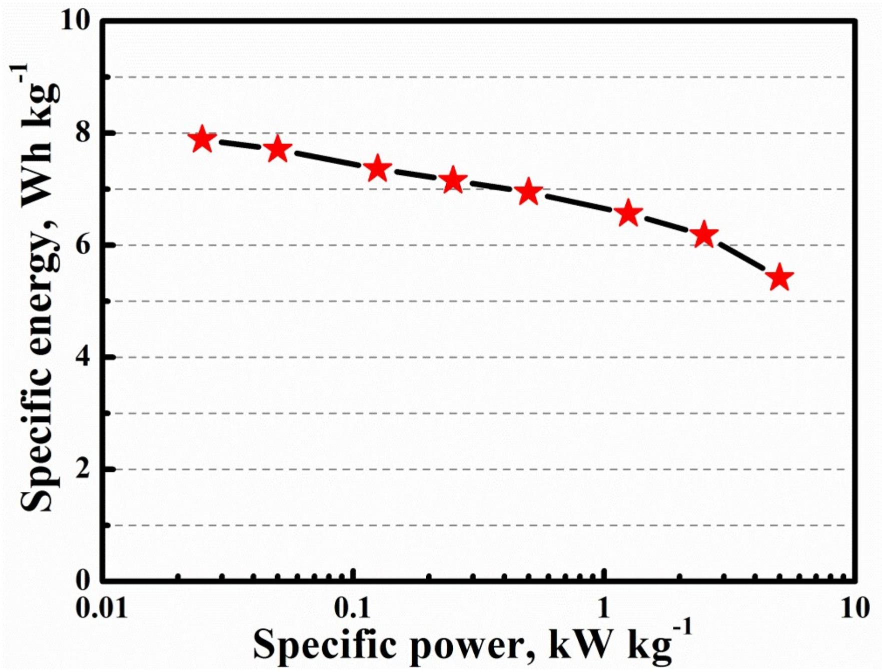

Fig. S8 Ragone plot of the "all-*kelp*" solid-state supercapacitor.

Table S2 Carbon electrode materials for all-solid-state supercapacitors

Electrode material	Doped	SSA (m^2 g^{-1})	Electrolyte	Capacitance (F g^{-1})	Reference
Kelp-derived activated carbon	—	4425	Na-alginate gel	227	This work
Graphene hydrogel film	—	414	PVA-H_2SO_4 gel	186	1
Carbon nanotubes	—	456	[EMIM][NTf_2]–silica gel	135	2
Graphene-cellulose paper	—	—	PVA-H_2SO_4 gel	120	3
3D graphene	—	1661	PVA-H_2SO_4 gel	80	4
Activated carbon fibers	—	1476	PVA-H_3PO_4 gel	43.8	5
Activated carbon cloth	—	61.2	PVA-H_2SO_4 gel	0.00155	6
Carbon nanofibers	*N*-	312	PVA-H_2SO_4 gel	175	7
Graphene aerogel	*N*,*B*-	249	PVA-H_2SO_4 gel	62	8

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Table S3 Comparison of the electrochemical performance of advanced all-solid-state supercapacitors with carbon-based materials reported in literatures. Here (E) represents the calculation method based on electrode level and (D) represents calculation method based on device level.

Electrode material	Gravimetric capacitance (F g^{-1})	Volumetric capacitance (F cm^{-3})	Volumetric energy density (Wh L^{-1})	Cycling retention	Reference
Kelp-derived AC	227	72.3 (E) 18.1 (D)	2.5	97% (10,000 cycles)	This work
Graphene hydrogel film	186	31 (E)	1.07	97.5% (10,000 cycles)	1
CNT fiber//CNT sheet	59	32.1 (E)	1.11	—	2
AC fiber	43.8	27.6 (D)	2.5	90.4% (10,000 cycles)	3
Carbon nanofiber	84	2.1 (D)	2.5	96% (10,000 cycles)	4
MWCNT/carbon microfiber	11.1	14.1 (E)	0.14	94% (1000 cycles)	5
AWC//WC@MnO_2	35.6	14.4 (D)	6.4	93% (10,000 cycles)	6
CNT/vanadium nitride	5.2	7.9 (D)	0.54	82% (10,000 cycles)	7
H-TiO_2@MnO_2//H-TiO_2@C	139.6	0.7 (D)	0.3	91.2% (5000 cycles)	8
AC//polypyrrole@MnO_2	261	19.3 (D)	8.67	98.6% (1000 cycles)	9
Graphene//Co_3O_4	117	2.1 (D)	0.62	84% (1000 cycles)	10

AC: activated carbon; CNT: carbon nanotube; MWCNT: multi-wall carbon nanotube; AWC: activated wood carbon; WC: wood carbon.

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