ADVANCED FUNCTIONAL MATERIALS

Supporting Information

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Aramid Nanofiber Membranes for Energy Harvesting from Proton Gradients

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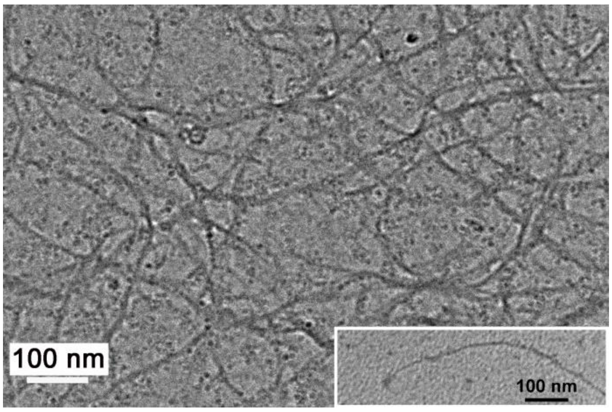

Figure S1. TEM images of the individual ANFs. The inset in the bottom shows a single aramid nanofiber.

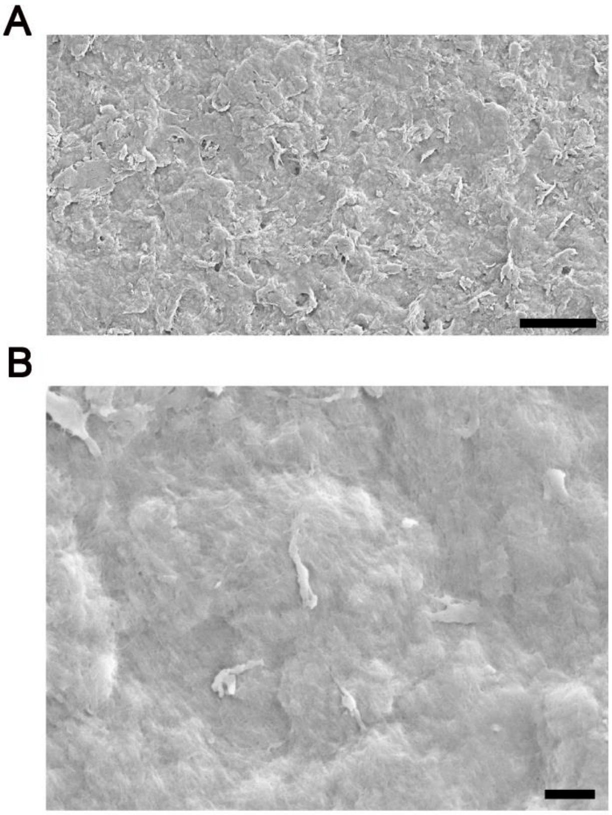

Figure S2. SEM images of the ANF membrane. The scale bars are 1μm (A) and 200 nm (B).

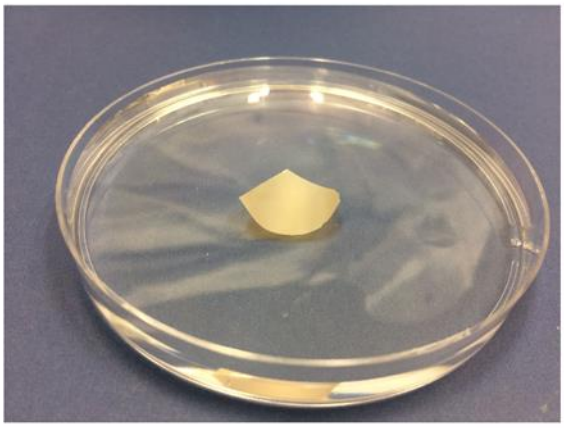

Figure S3. Representative photograph of the ANF membrane after soaking in 1 M HCl for one week.

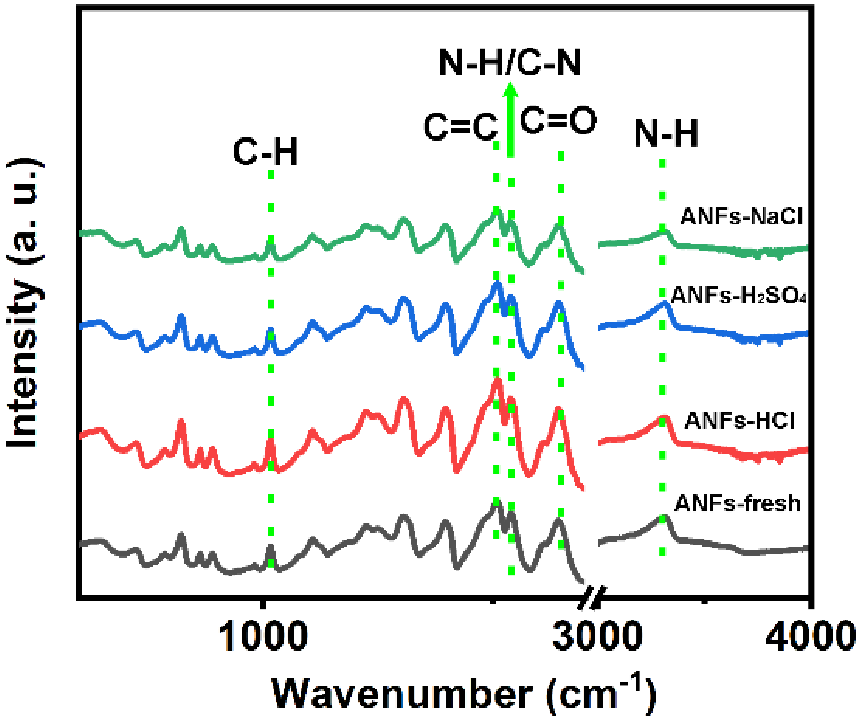

Figure S4. FTIR spectra of ANF membranes after treatment with 1M solutions of HCl, H_2SO_4, and NaCl for one week.

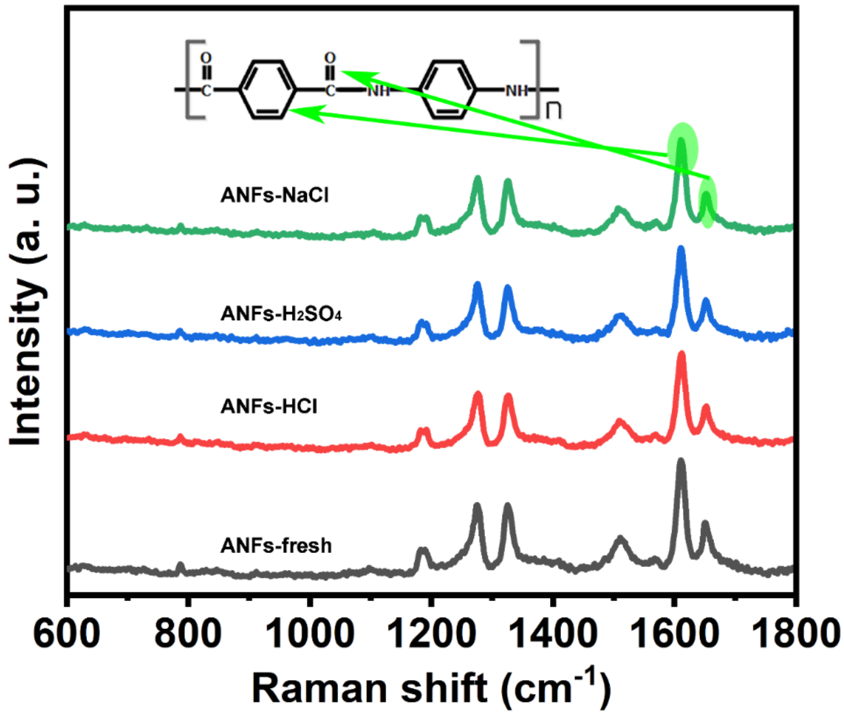

Figure S5. Raman scattering spectra of ANF membranes after one-week treatment with 1M solutions of HCl, H_2SO_4, and NaCl.

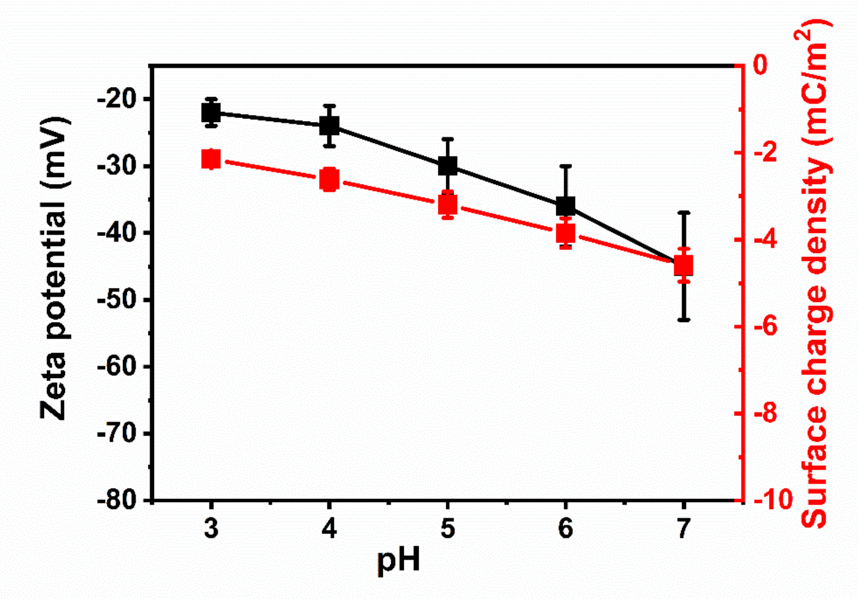

Figure S6. Zeta potential of the ANFs membrane in KCl.

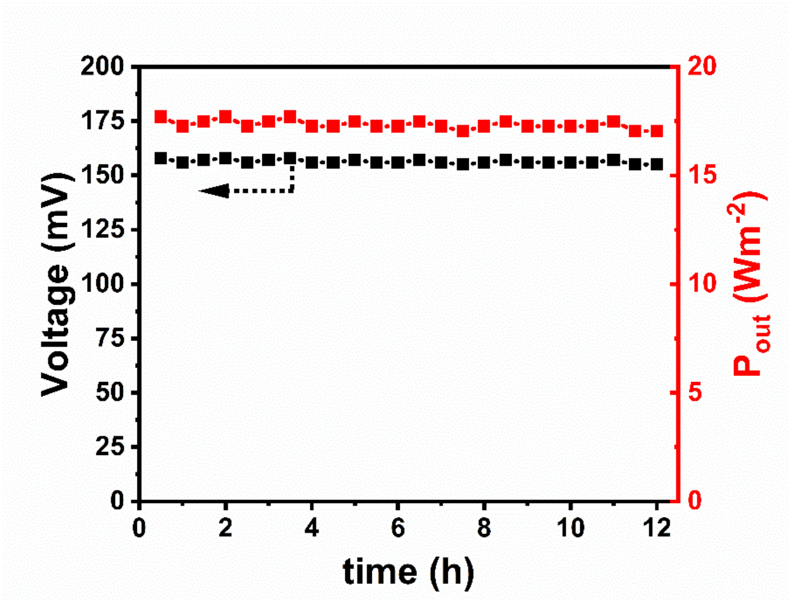

Figure S7. The continuous energy output.

Table S1. The cation selectivity caclulation for the ioninc transport through ANF membranes.

Electrolyte	C_l (M)[a]	C_h (M)	E_{redox} (mV)	$E_{zero\text{-}current\ voltage}$ (mV)	$E_{osmotic}$ (mV)	$S_{selectivity}$	t^+
HCl	0.001	1	180	300	120	0.677	0.838
KCl	0.001	1	155	196	41	0.232	0.616

a: M means $molL^{-1}$.

Table S2. The specific values of maximum power output of ANF membranes in various electrolytes.

a: M means $molL^{-1}$.

Electrolyte	**Concentration (M)**[a]	**R_{max} (kΩ)**	**P_{max} (W m^{-2})**
HCl	10^{-3} - 1	47	17.28
KCl		200	2.35
H_2SO_4		100	1.06
H_3PO_4		100	0.70

Table S3. Elaboration of different electrochemical contributions to the concentration energy harvesting device.

Electrolyte	$I_{measured}$ (μA)	7.6
HCl (10^{-3}-1 molL^{-1})	I_{redox} (μA)	4.4
	$I_{osmotic}$ (μA)	3.2
	$V_{measured}$ (mV)	310
	V_{redox} (mV)	180
	$V_{osmotic}$ (mV)	130
	$P_{calculated}$ (Wm^{-2})	19.6
	$P_{osmotic}$ (Wm^{-2})	3.5

Table S4. The comparison of various membranes with different active areas for osmotic energy harvesting.

Membrane	Thickness (μm)	Electrolyte	Power (W m^{-2})	Active area Region	Working time	Ref.
single-layer molybdenum disulfide	0.65 nm	0.001-1.0 M KCl	10^6	nm x nm	1 h	1
BNNT	1	0.001-1.0 M KCl	4000	nm x nm	/	2
Conical Pores	12	0.001-0.5 M KCl	945	μm x μm	/	3
PES-Py/HS20	11	0.01-5.0 M NaCl	5.1	μm x μm	120 h	4
MXene/Kevlar	4.5	0.01-0.5 M NaCl	4.1	μm x μm	32 d	5
ionic diode membrane (mesoporous carbon and macroporous alumina)	4.2 + 60[a]	0.01-0.5 M NaCl	3.46	μm x μm	/	6
Polymer/Graphene Oxide	1 + 30[b]	0.01-0.5 M NaCl	0.76	μm x μm	/	7
Fumasep FAD and FKD	82	0.01-0.5 M NaCl	0.7	cm x cm	/	8
FKS as CEM and FAS as AEM （Stacks of anion	30-40	0.01-0.5 M NaCl	1.2	cm x cm	/	9

and cation exchange membranes)						
Charged Graphene oxide membrane pairs	10	0.01-0.5 M NaCl	0.77	mm x mm	16 h	10
ABN	1	0.01-0.5 M NaCl	0.40	mm x mm	200 h	Joule
ANFs	10	0.001-1.**0 M** HCl	17.3	0.03 mm x mm	240 h	This work
ANFs	10	0.001-1.**0 M** HCl	1.02	3.14 mm x mm	4 h	This work
ANFs	10	0.001-1.**0 M** HCl	0.20	19.625 mm x mm	4 h	This work
ANFs	10	0.001-1.**0 M** HCl	0.16	78.5 mm x mm	4 h	This work

Note: a: 2-μm-thick MesoClayer is attached on the top of a 60-μm-thick MacroA substrate.

b: 1 μm PPSU-Pyx was casted on 30 μm GO membrane.

Table S5. Maximum power output of ANF membranes in HCl solution under various temperatures.

Electrolyte	**Temperature (K)**	$\mathbf{R_{max}}$ **(kΩ)**	$\mathbf{P_{max}}$ **(W m^{-2})**
HCl (10^{-3} -1 M)	298	47	17.28
	323	12	63
	343	12	77

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