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

Supporting Information

Enhancing Energy Extraction from Water Microdroplets through Synergistic Electrokinetic and Galvanic Effects

Haitao Li,[a] Wenxing Wang,[b] Xiangming Li,[b] Tharishinny Raja-Mogan,[c] Linan Xu,[d] Hiang Kwee Lee,*[c,e] and Jie Han*[a]*

[a]*School of Chemistry and Chemical Engineering, Yangzhou University, Yangzhou, 225002, PR China.*

[b]*Department of Functional Materials, School of Materials Sciences and Technology, Guangdong University of Petrochemical Technology, Maoming, 525000, China.*

[c]*Division of Chemistry and Biological Chemistry, School of Chemistry, Chemical Engineering and Biotechnology, Nanyang Technological University, 21 Nanyang Link, 637371 Singapore*

[d]*College of Materials Engineering, North China Institute of Aerospace Engineering, Langfang 065000, China*

[e]*Institute of Materials Research and Engineering, The Agency for Science, Technology and Research (A*STAR), 2 Fusionopolis Way, #08-03, Innovis 138634, Singapore*

Corresponding Author

E-mail address: htli@yzu.edu.cn (Haitao Li); hiangkwee@ntu.edu.sg (Hiang Kwee Lee); hanjie@yzu.edu.cn (Jie Han)

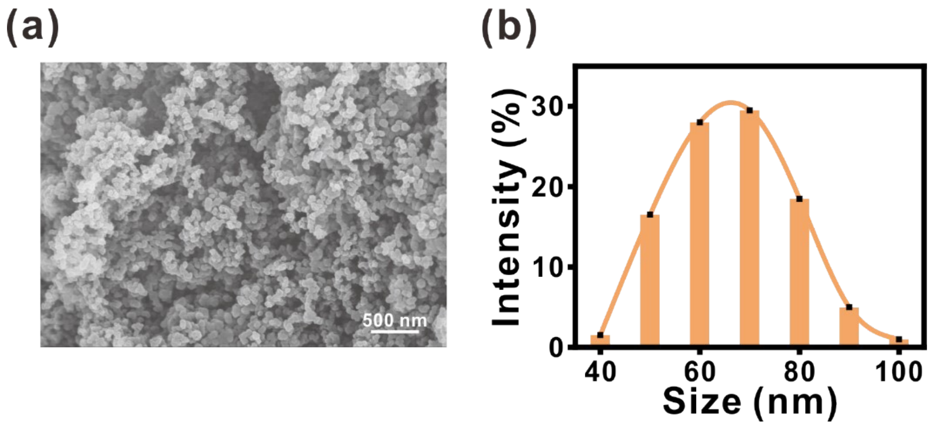

Figure S1. **(a)** SEM image of Ketjen carbon black (KCB) and **(b)** the corresponding size distribution.

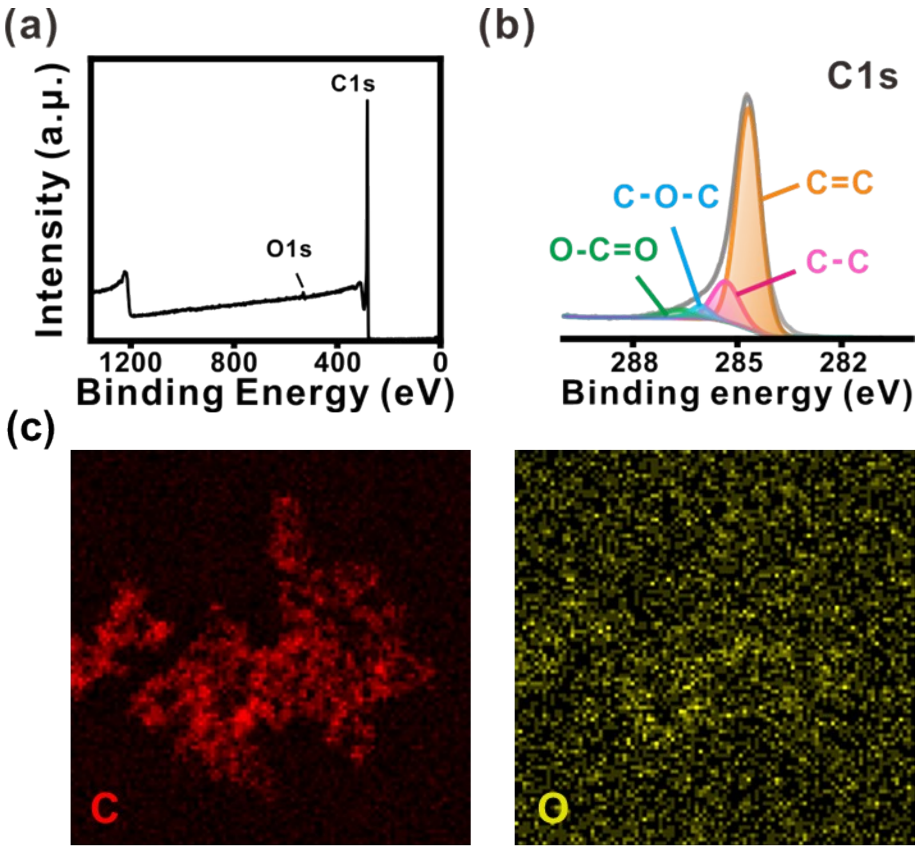

Figure S2. **(a)** XPS survey spectrum of KCB. **(b)** High resolution C1s spectrum of KCB. **(c)** TEM EDS mapping of C and O elements on KCB.

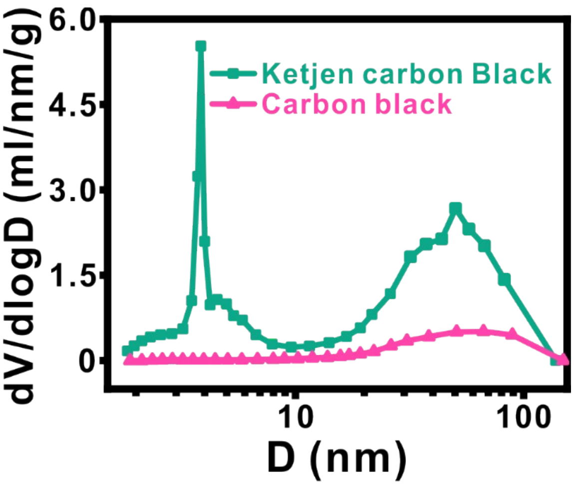

Figure S3. Pore size distributions of KCB and CB.

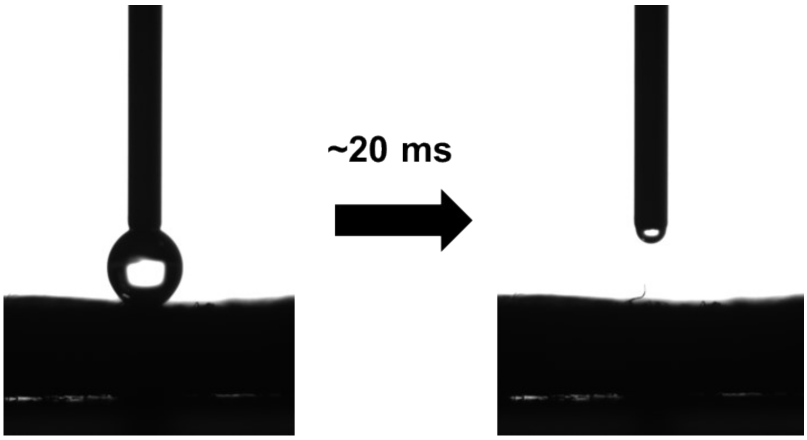

Figure S4. Side view images showing the rapid absorption process of 4 μL deionized (DI) water upon addition onto the cotton cloth loaded with KCB material.

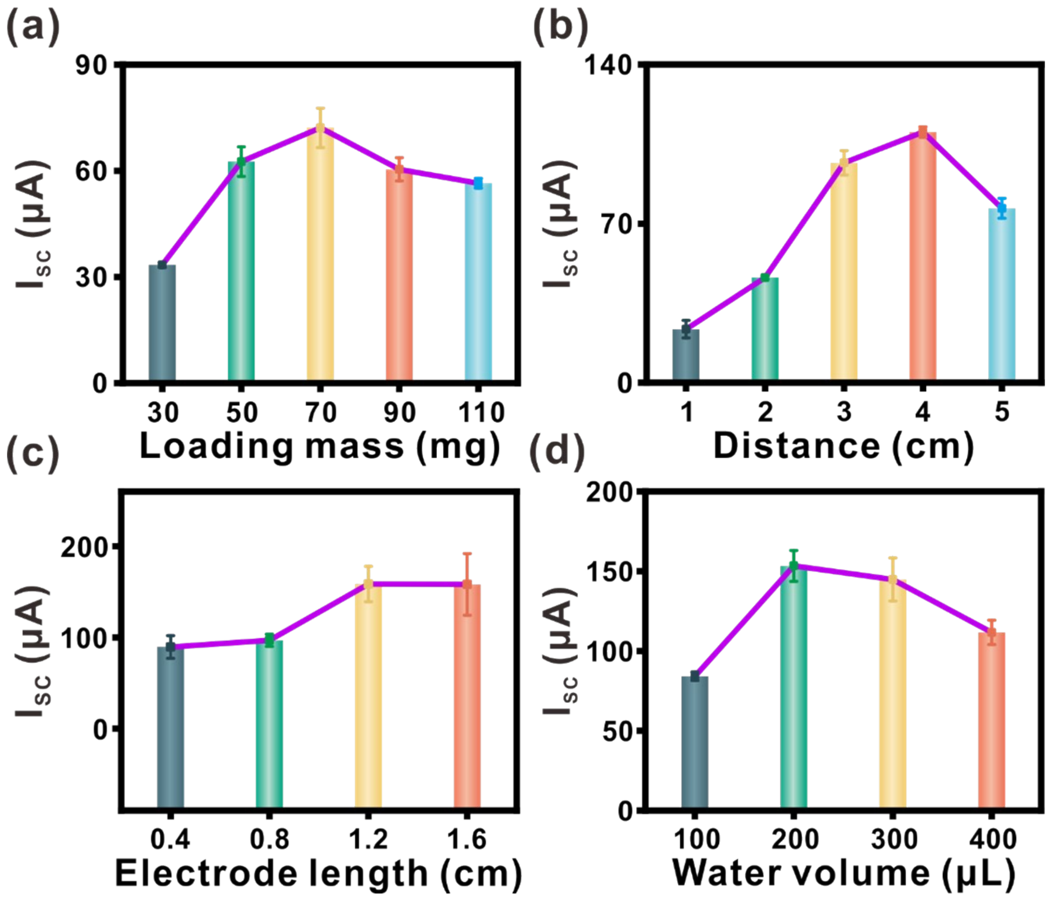

Figure S5. Evaluation of power generation performance of our designed WEG with varying preparation parameters and under various water consumption. I_{SC} of WEG with various **(a)** KCB mass loading (30-110 mg), **(b)** electrode spacing (1-5 cm), **(c)** electrode length (0.4-1.6 cm), and **(d)** water consumption (100-400 μL). All tests are carried out under normal laboratory environment (~25 °C, ~50 %RH).

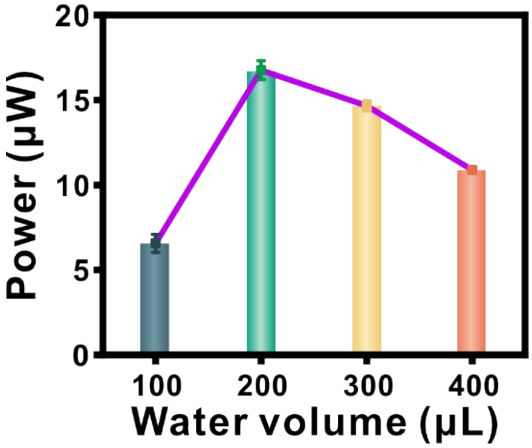

Figure S6. Power of WEG using different volume of water (at 25 ℃ and 50 %RH).

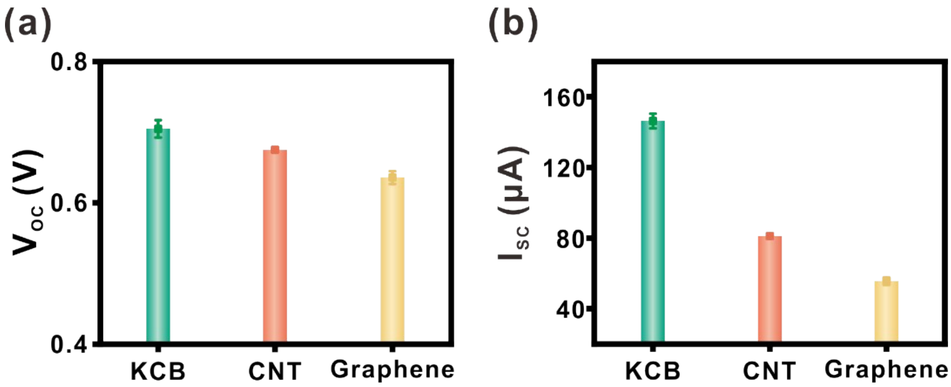

Figure S7. (a) V_{OC} and **(b)** I_{SC} of WEG designed using KCB, CNT and graphene detected under 200 μL DI water (at 25 °C; 50 %RH).

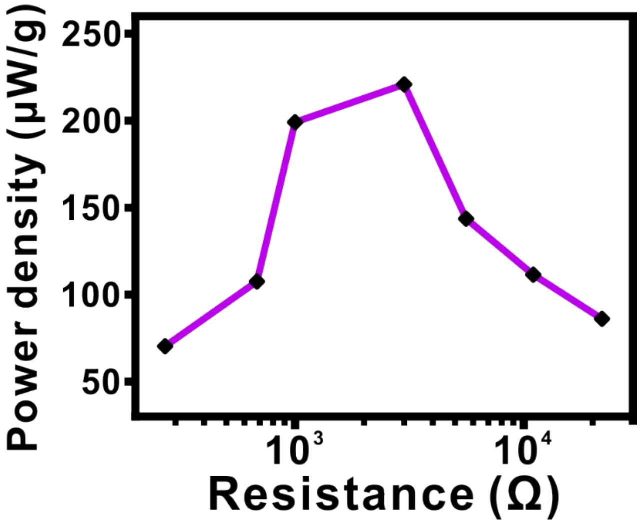

Figure S8. Power density of the optimized WEG when subjected to different external resistances (200 μL) at 50 %RH humidity and 25 °C.

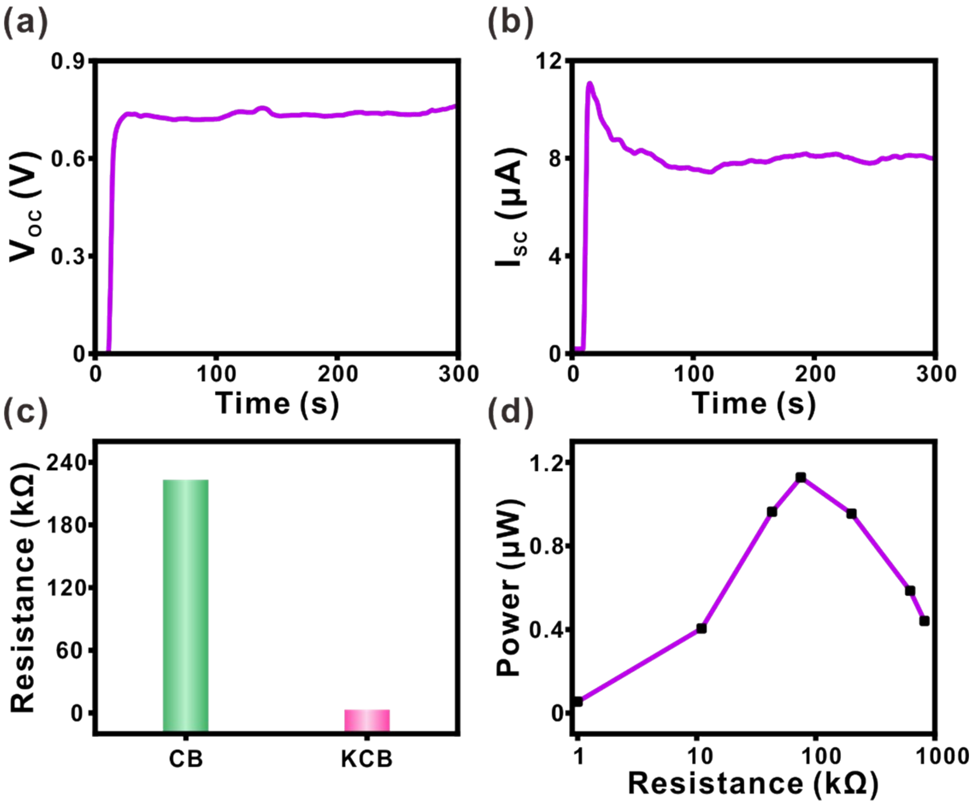

Figure S9. (a) V_{OC} and **(b)** I_{SC} of WEG designed using common carbon black (CB). **(c)** Comparison of internal resistance of WEG using KCB and CB. **(d)** Power output under different external resistances of WEG using CB. All tests are carried out under laboratory environmental conditions at 25 °C and 50 %RH.

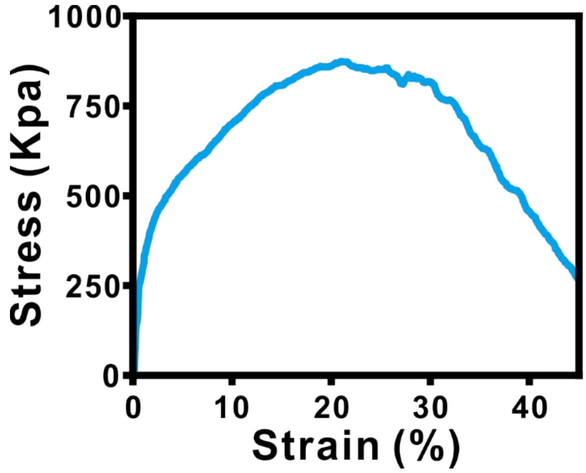

Figure S10. The tensile strain-stress curve of WEG.

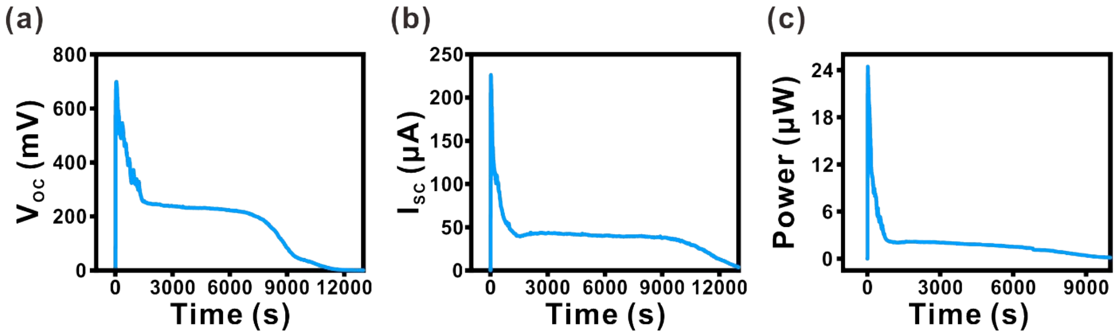

Figure S11. Long-term electrical performance test of WEG in DI water (200 μL). **(a)** V_{OC}, **(b)** I_{SC} and **(c)** output power of WEG. The WEG is subjected to an environment at 50 %RH humidity and 25 ℃.

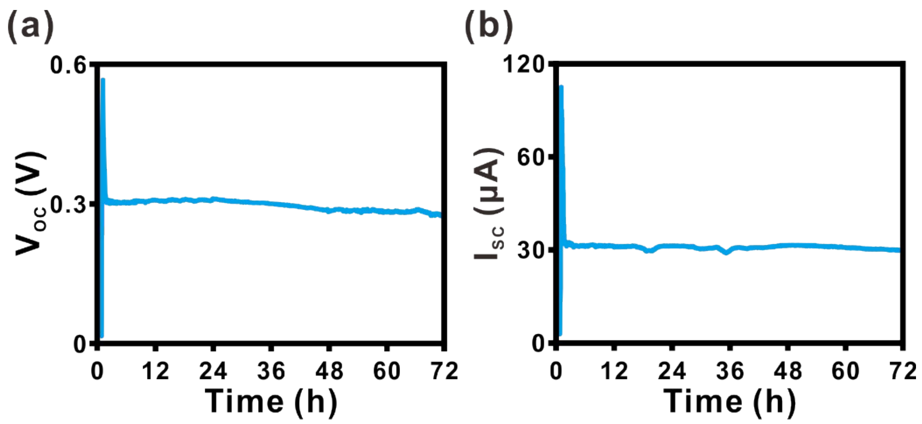

Figure S12. The long-term stability of the WEG device. **(a)** V_{OC} and **(b)** I_{SC} of WEG. The WEG is subjected to an environment at 50 %RH humidity and 25 °C.

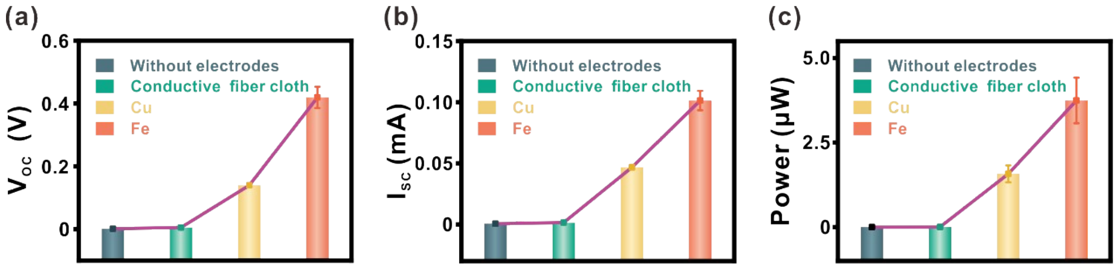

Figure S13. (a) V_{OC}, **(b)** I_{SC} and **(c)** output power of WEG with different electrodes or without electrodes in deionized water. The test environment is controlled at 25 °C under 50 %RH humidity.

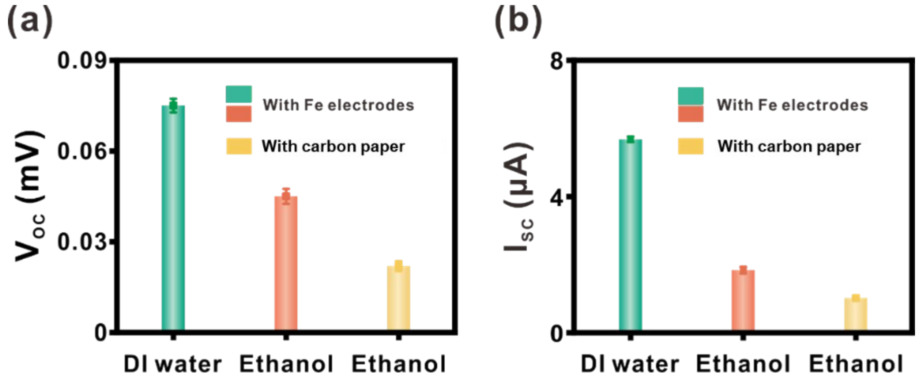

Figure S14. (a) V_{OC} and **(b)** I_{SC} of WEG using with Fe electrodes and carbon paper electrodes when recorded under DI water and ethanol (25℃; 50 %RH).

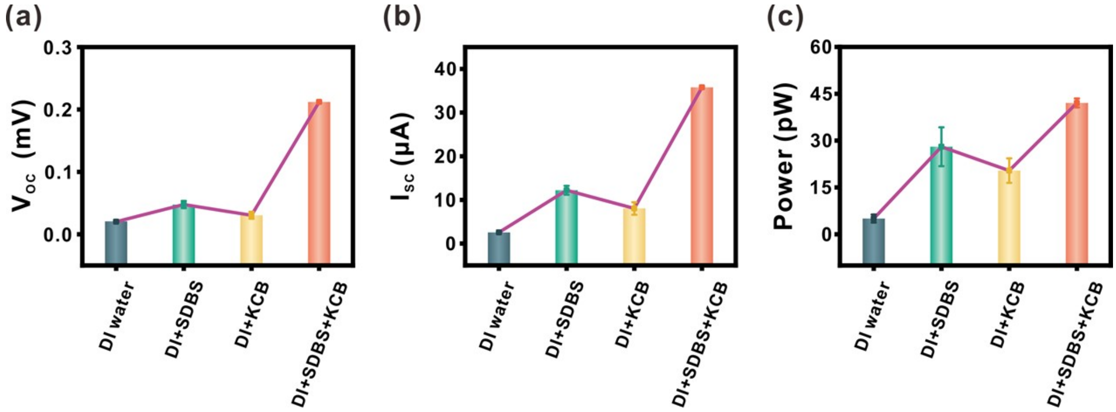

Figure S15. Electrical properties of control WEG setup comprising of conductive carbon cloth with attached iron electrodes. **(a)** V_{OC}, **(b)** I_{SC} and **(c)** maximal output power of the control WEG in DI water, DI water with SDBS, DI water with KCB, and water with SDBS and KCB. All tests are carried out under laboratory environmental conditions, 25 ℃ and 50 %RH.

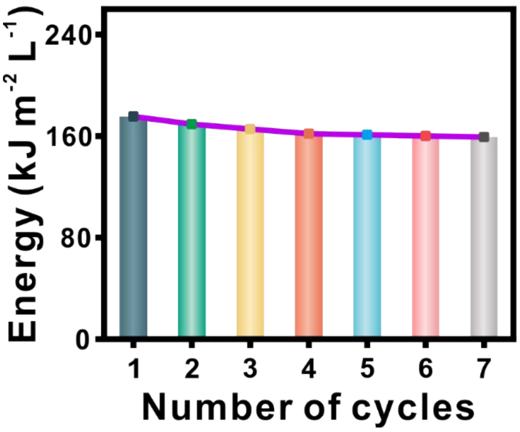

Figure S16. Energy output of WEG in DI water (200 μL) over seven cycles at 50 %RH humidity and 25 ℃.

The cyclability test was conducted in a closed container with constant temperature and humidity. The output performance of the material was continuously monitored using the Keithley 2450 multimeter. In each cycle, a drop of 200 μL of DI water was used until it has completely evaporated. This was followed by the addition of the next water droplet, and the process continued until the end of the test.

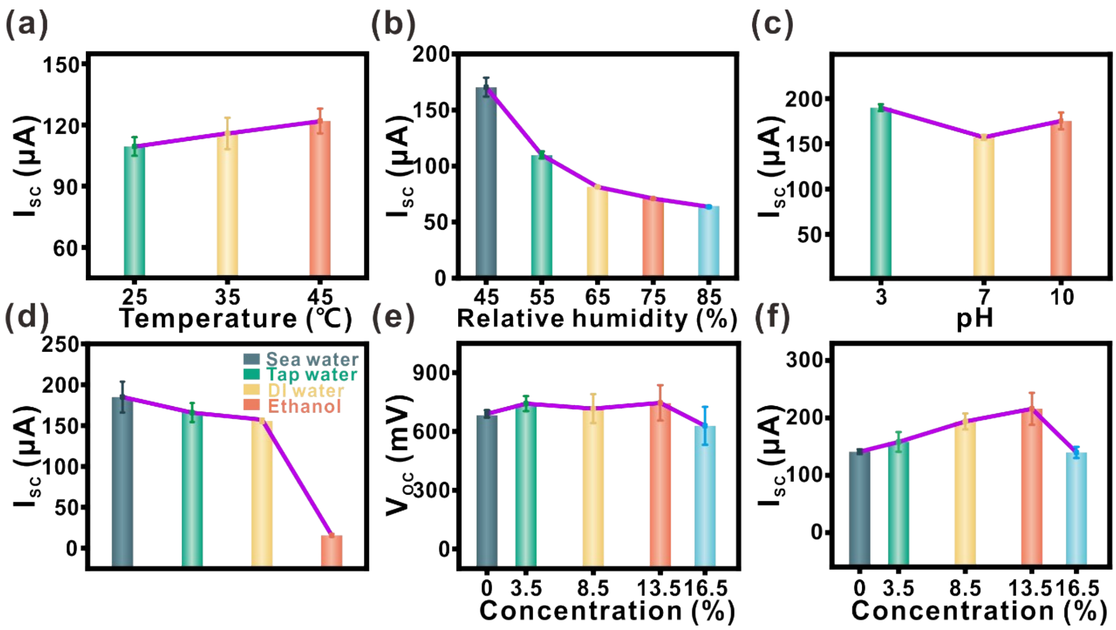

Figure S17. Evaluation of the power generation performance of the optimized WEG under different factors. **(a)** I_{SC} of WEG under various temperatures (25-45 °C) at 50 %RH. **(b)** I_{SC} of WEG at different relative humidity (45-85 %RH) at room temperature. **(c)** I_{SC} of WEG in aqueous solution with different pH (pH =3, 7, 10) at room temperature and 55 %RH. **(d)** I_{SC} of WEG when using different solutions at room temperature and 50 %RH. **(e)** V_{OC} and **(f)** I_{SC} of WEG achieved using NaCl solution with different salt concentration at room temperature and 55 %RH.

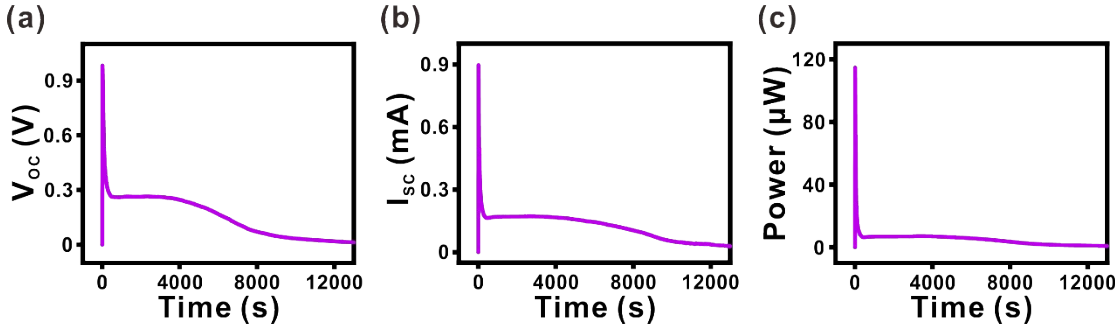

Figure S18. Durability test on WEG performance in 13.5 wt% NaCl solution. **(a)** V_{OC}, **(b)** I_{SC} and **(c)** output power of WEG. All tests are carried out under laboratory environmental conditions, 25 ℃ and 50 %RH.

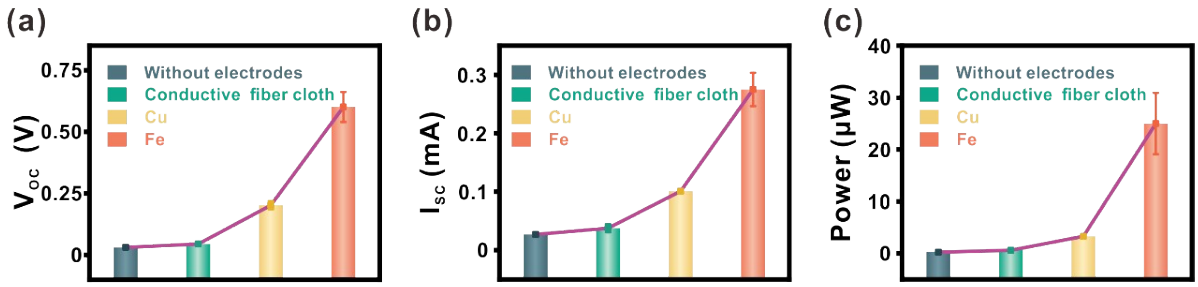

Figure S19. (a) V_{OC}, **(b)** I_{SC} and **(c)** maximal output power of WEG with different electrodes or without electrodes in 13.5 wt% NaCl solution. All tests are carried out under laboratory environmental conditions, 25 ℃ and 50 %RH.

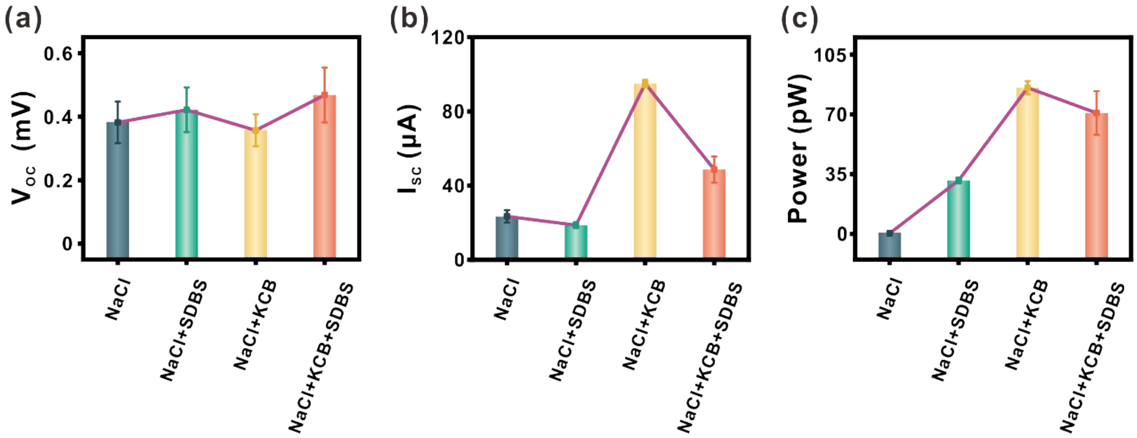

Figure S20. (a) V_{OC}, **(b)** I_{SC}, and **(c)** maximal output power of control WEG platform comprising of conductive carbon cloth and attached iron electrodes. Test solutions include NaCl solution, NaCl solution with SDBS, NaCl solution with KCB, and NaCl solution with SDBS and KCB. The concentration of all NaCl solutions is at 13.5 wt%. All tests are carried out under laboratory environmental conditions, 25 °C and 50 %RH.

Table S1. Maximal output performance comparison with previous reports.

Materials	Solution	V_{OC} (mV)	I_{SC} (μA)	P (μW)	A (cm^2)	P/A (μW/cm^2)	Ref.
CNT/Mxene	3.5 wt% NaCl solution	360	520	46.63	30	1.55	1
LiCl/cellulon paper/CB	Moisture	780	7.5	6.3	3×3 cm^2	0.7	2
CB/cotton	DI water	530	3.91	0.255	9×3 cm^2	0.01	3
rGO	0.6 M NaCl solution	/	/	2.73	1.5 ×2.0 cm^2	0.91	4
PVA/FCB/3DS	water	658	63	8.1	3×4 cm^2	0.675	5
CNMs	water	0.284±0.005	9.36±0.84	0.664	4×2 cm^2	0.083	6
CB/cotton/$CaCl_2$	DI water	1200	5	5.5	4×2 cm^2	0.687	7
Al_2O_3	DI water	2500	0.79	/	18×4 cm^2	0.513	8
rGO/sponge	water	630	50.75	17.3	4-30	1.74	9
Sugarcane	sea water	470	8.2	0.44	12	0.027	10
KCB/cotton	DI water	640	140	18	4×2 cm^2	2.25	This work
KCB/cotton	13.5 wt% NaCl solution	1000	600	122.4	4×2 cm^2	15.3	This work

Calculation of the power generation efficiency (extractable energy) of the designed device. The detailed calculation process is as follows:

$$E_{in} = \int P_t dt \tag{1}$$

$$E_s = \frac{1}{2}CV^2 \tag{2}$$

Where E_{in} is the energy output by WEG; E_s is the energy stored in capacitor (for practical use) after charging; P_t is the instantaneous power; t is the charging time (20 minutes); C is the capacity of the capacitor (0.5 F), and V is the voltage charged into the capacitor (~0.5 V).

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