Supporting Information

Effect of gel ageing and electrode corrosion on the performance of direct laser writing carbonization enabled hydrogel-based moist-electric generator

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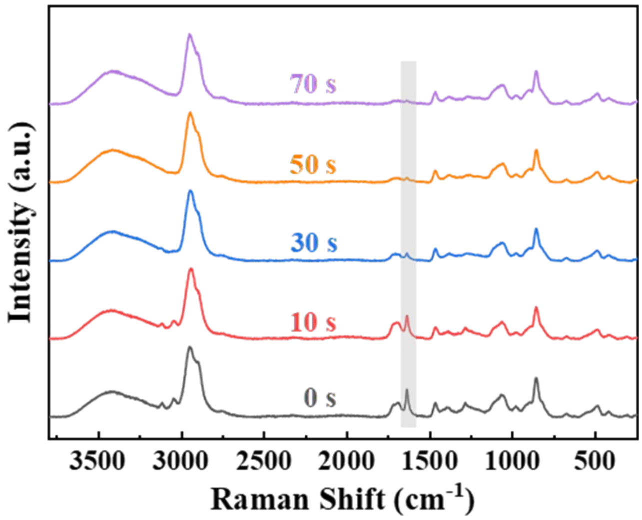

Figure S1. Raman spectra for tracking the polymerization of AA in the solution of PVA/AA/PA (solution aged for 2.5 days) initiated by UV irradiation for different time duration.

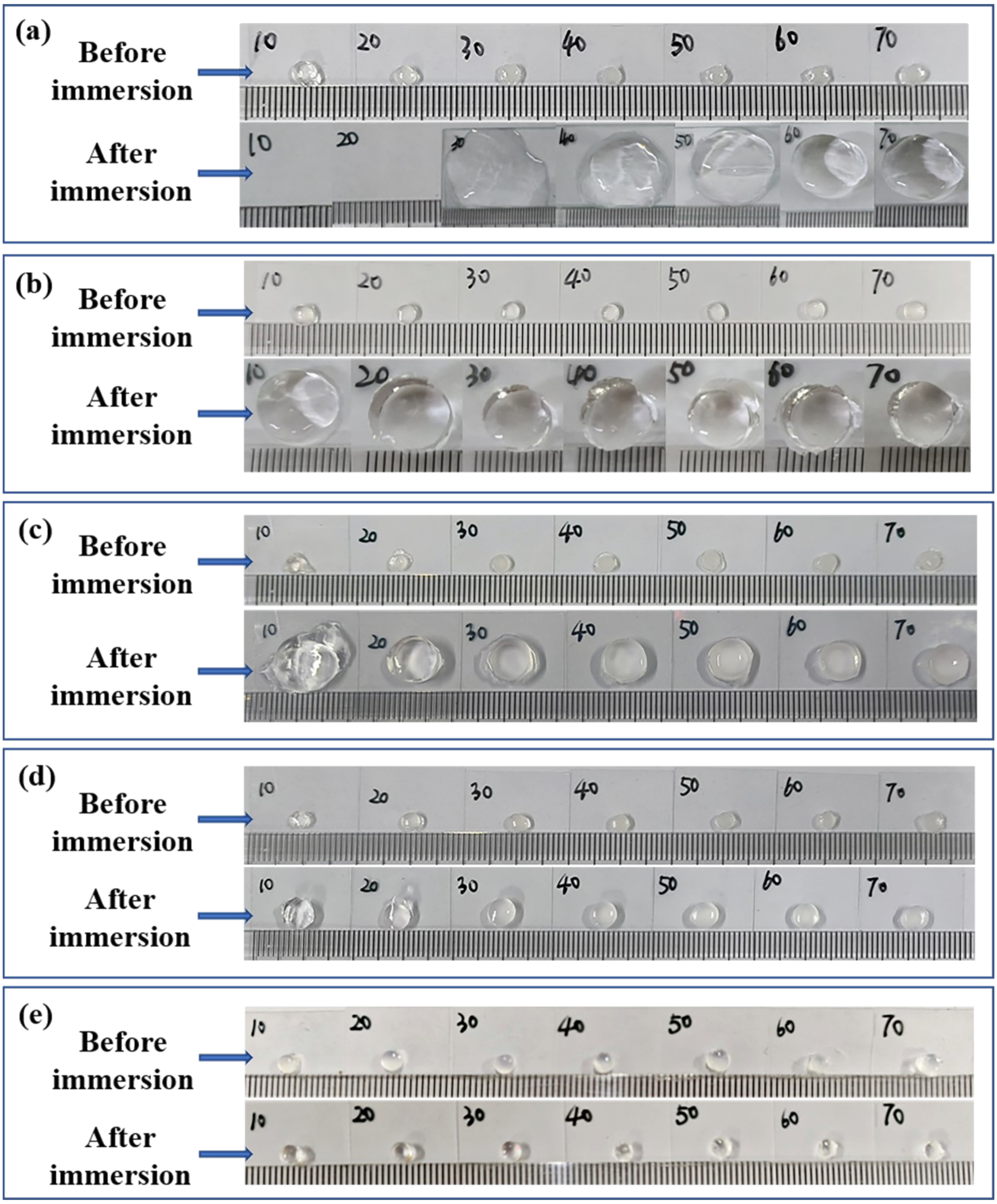

Figure S2. Optical pictures to show the effect of solution and gel ageing on water immersion (24 h) induced swelling for the PVA/PAA/PA hydrogel prepared by UV irradiation for varied time duration (The scale of the ruler is 1 mm; the number labeled in each picture indicates the UV-irradiation time). (a) Solution ageing for 0.5 day without gel ageing; (b) Solution ageing for 2.5 days without gel ageing; (c) Solution ageing for 0.5 day and gel ageing for 24 h; (d) Solution ageing for 2.5 days and gel ageing for 24 h; (e) Solution ageing for 120 days and gel ageing for 0 h.

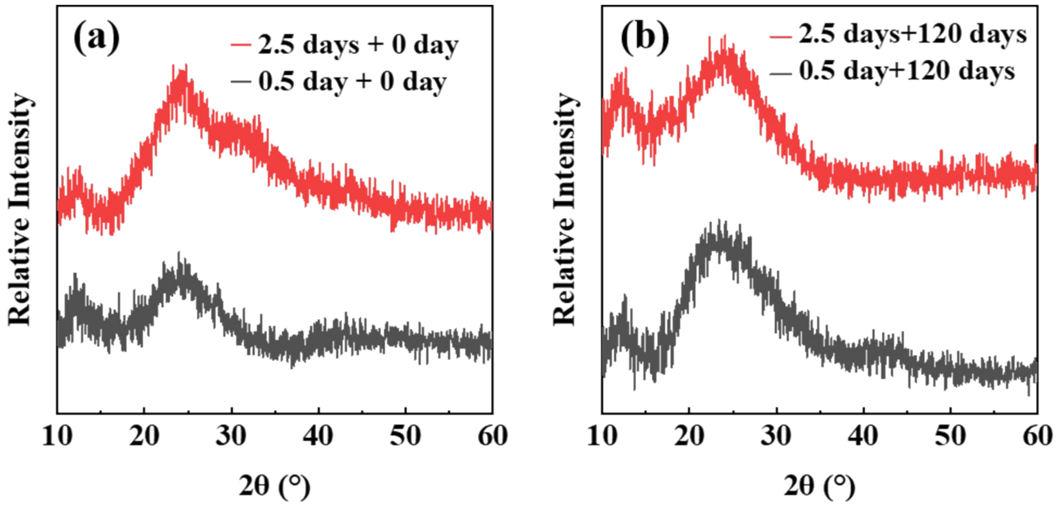

Figure S3. X-ray diffraction pattern of the PVA/PAA/PA hydrogels prepared from the solution aging for 0.5 or 2.5 days upon UV irradiation for 30 s and (a) without and (b) with gel aging treatment.

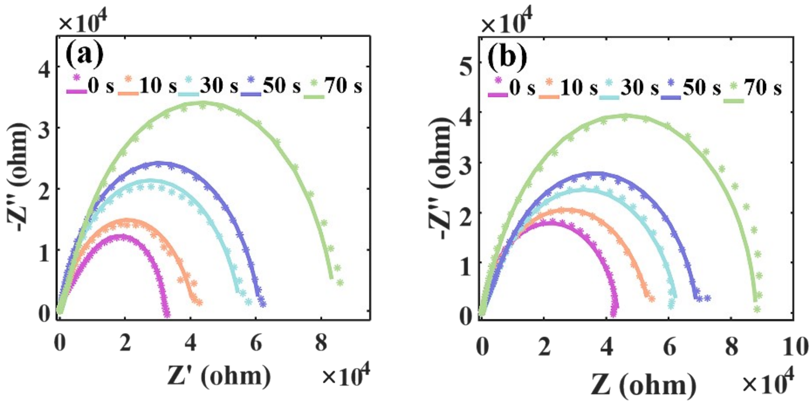

Figure S4. The complex plane impedance diagram of PVA/PAA/PA hydrogel prepared from the PVA/AA/PA solution aged for (a) 2.5 days or (b) 120 days, and UV-exposure for varied time duration (no gel ageing treatment). Scattered data points are the experimentally measured results; and the continuous lines are the equivalent circuit fitting results (See Figure 4a for the circuit diagram).

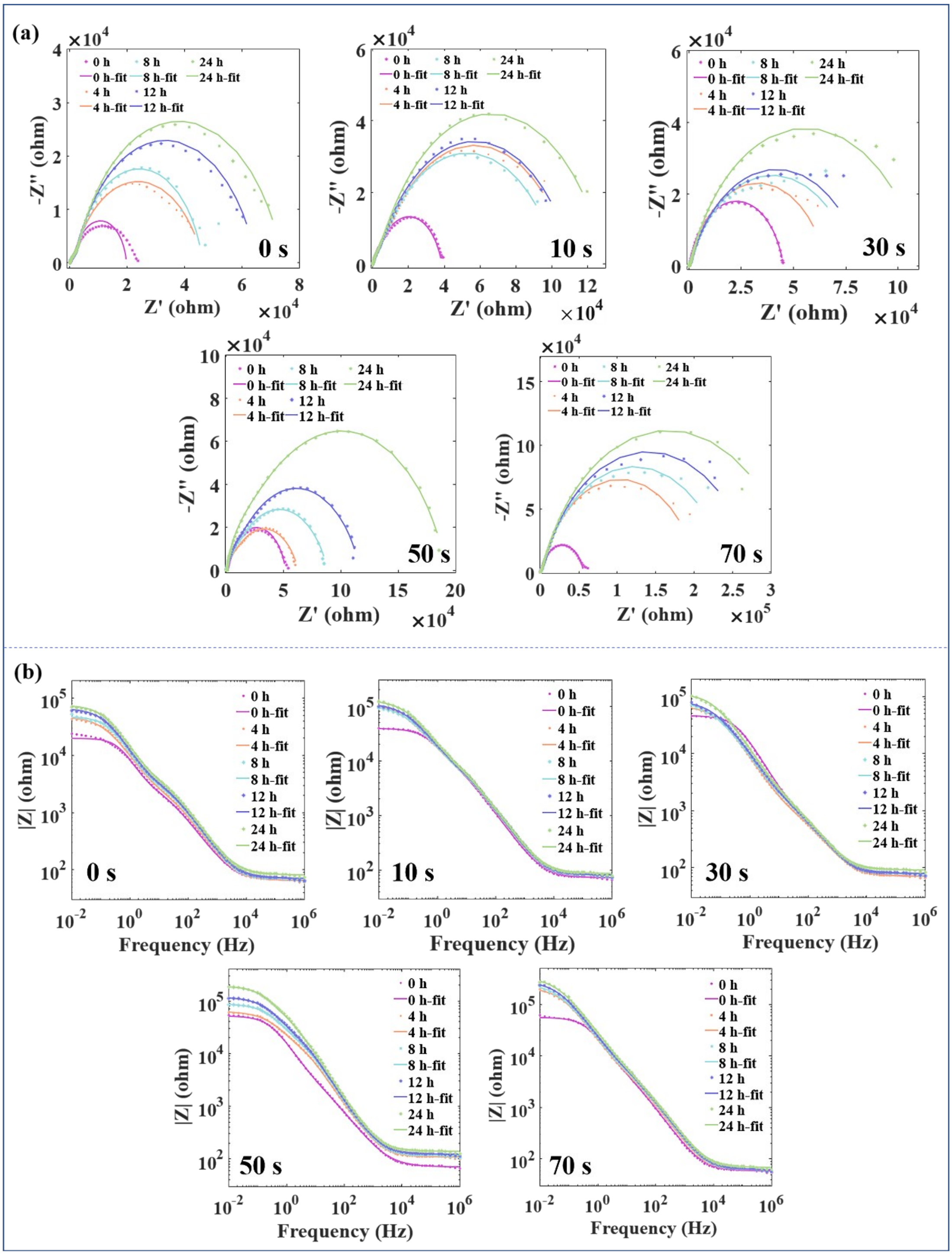

Figure S5. (a) The complex plane and (b) Bode impedance diagrams for the PVA/PAA/PA hydrogels prepared by UV-irradiation for varied time duration (0 s, 10 s, 30 s, 50 s and 70 s) and aged at different conditions. The PVA/AA/PA solution ageing time is 0.5 day; and the PVA/PAA/PA gel ageing time varies from 0 h to 24 h. Scattered data points are the experimentally measured results; and the continuous lines are the equivalent circuit fitting results (See Figure 4a for the circuit diagram).

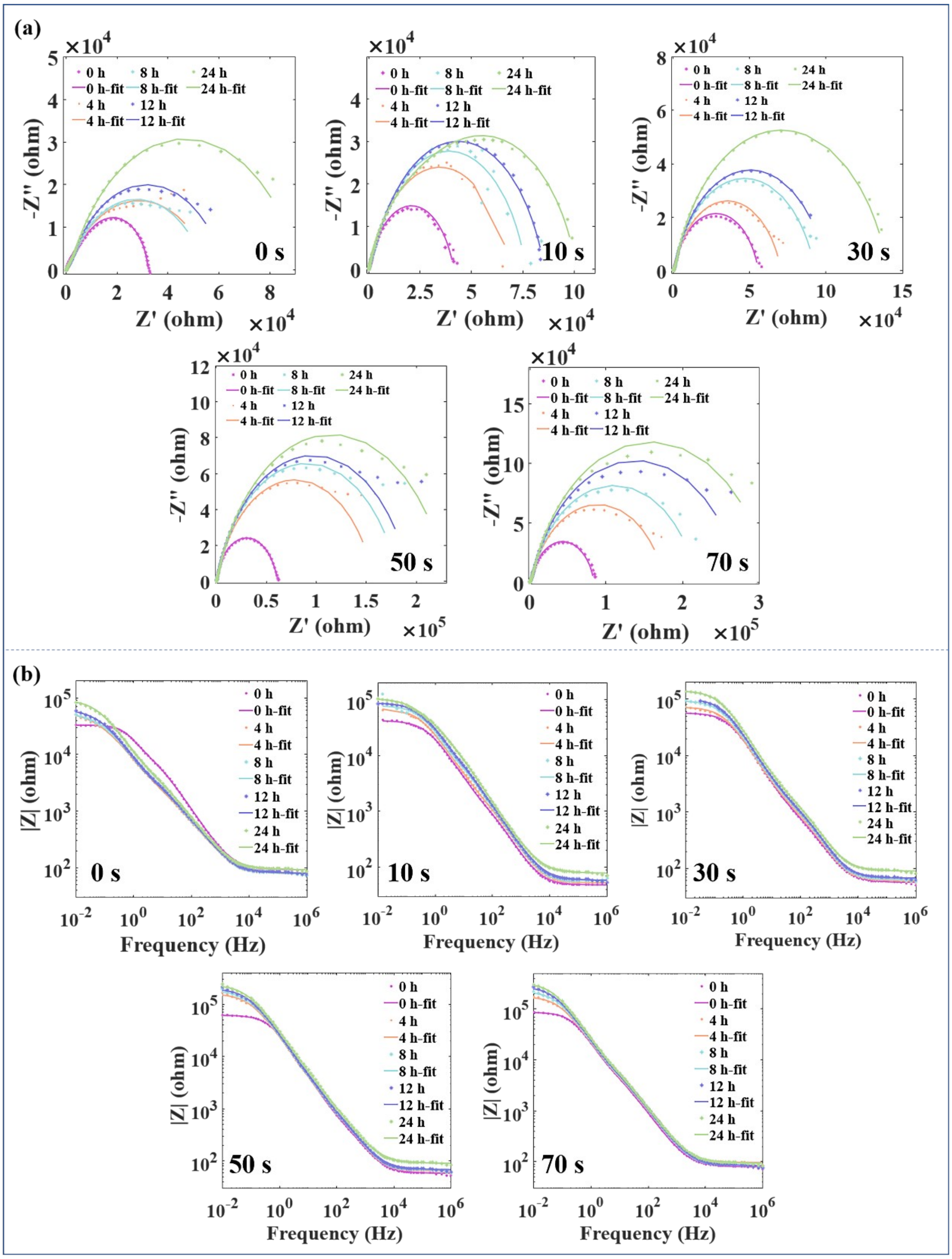

Figure S6. (a) The complex plane and (b) Bode impedance diagrams for the PVA/PAA/PA hydrogels prepared by UV-irradiation for varied time duration (0 s, 10 s, 30 s, 50 s and 70 s) and aged at different conditions. The PVA/AA/PA solution ageing time is 2.5 days; and the PVA/PAA/PA gel ageing time varies from 0 h to 24 h. Scattered data points are the experimentally measured results; and the continuous lines are the equivalent circuit fitting results (See Figure 4a for the circuit diagram).

Table S1. Summary of the equivalent circuit (inset of Figure 4a) fitting results for the experimentally measured impedance spectra shows in Figure S3 – S5.

Solution Aging Time (d)	UV exposure time (sec)	Gel Aging Time (h)	R3 (ohm)	R1 (ohm)	R2 (ohm)	CPE1-T (F)	CPE1-P	CPE2-T(F)	CPE2-P
0	**0**	0	49	437	19059	1.57E-05	0.76229	2.46E-05	0.75932
	10	0	68	3815	18932	7.31E-06	0.76987	1.90E-05	0.87104
	30	0	57	1186	40468	2.03E-05	0.69320	1.29E-05	0.86426
	50	0	57	330	45824	1.26E-05	0.84111	7.32E-06	0.80431
	70	0	64	811	57820	1.90E-05	0.76557	5.36E-06	0.85417
0.5	**0**	0	65	1036	21632	1.31E-05	0.75020	2.63E-05	0.76793
		4	64	1630	41595	1.17E-05	0.74084	2.34E-05	0.79949
		8	67	2008	46884	9.50E-06	0.75093	2.00E-05	0.82199
		12	70	2128	59760	8.97E-06	0.75152	1.83E-05	0.82114
		24	80	2481	68166	8.39E-06	0.74972	1.58E-05	0.83032
	10	0	70	3406	36177	1.54E-05	0.72657	1.18E-05	0.78694
		4	77	4083	102760	1.24E-05	0.75163	1.72E-05	0.71450
		8	77	3826	96274	1.18E-05	0.75136	1.58E-05	0.72313
		12	79	4163	103980	1.17E-05	0.74192	1.43E-05	0.74265
		24	83	4087	124730	1.19E-05	0.73484	1.26E-05	0.75334
	30	0	70	544	44561	2.04E-05	0.70251	1.20E-05	0.86065
		4	69	536	65571	2.10E-05	0.71729	2.75E-05	0.77915
		8	75	462	79094	1.84E-05	0.76802	2.88E-05	0.72263
		12	77	401	83196	1.74E-05	0.76519	2.53E-05	0.73071
		24	89	599	110560	2.07E-05	0.73063	2.01E-05	0.77271
	50	0	69	1295	50690	2.67E-05	0.67546	1.25E-05	0.83742
		4	105	4434	58252	7.19E-06	0.95193	1.12E-05	0.73516
		8	114	5489	83167	6.07E-06	0.96729	8.68E-06	0.75226
		12	121	6843	110310	5.81E-06	0.96085	7.65E-06	0.76202
		24	138	14107	177770	6.56E-06	0.94379	5.52E-06	0.78862
	70	0	58	1753	55190	1.34E-05	0.76302	8.23E-06	0.85588
		4	60	2235	203480	1.15E-05	0.76828	1.14E-05	0.79127
		8	61	1938	241780	1.12E-05	0.77524	1.10E-05	0.76474
		12	62	2015	276980	1.19E-05	0.76583	1.00E-05	0.76438
		24	67	1218	329190	1.19E-05	0.78401	8.56E-06	0.75780
2.5	**0**	0	91	7604	24634	8.30E-06	0.75923	1.23E-05	0.93826
		4	77	641	56275	3.11E-05	0.73974	3.50E-05	0.66610
		8	78	1233	53143	2.83E-05	0.70100	3.16E-05	0.70846
		12	80	1400	61122	2.42E-05	0.69866	3.01E-05	0.73530
		24	91	2212	89194	2.41E-05	0.68960	2.36E-05	0.76762
	10	0	48	397	40949	1.01E-05	0.84872	9.28E-06	0.79671
		4	52	499	68187	8.83E-06	0.85104	8.89E-06	0.77645
		8	56	1993	74652	1.29E-05	0.76689	7.63E-06	0.80887
		12	58	1984	83585	1.70E-05	0.76301	7.03E-06	0.79005

		24	78	25954	75286	7.62E-06	0.76561	1.22E-05	0.78418
	30	0	55	525	54964	1.41E-05	0.76048	1.04E-05	0.83872
		4	59	595	70064	1.06E-05	0.79154	1.11E-05	0.81439
		8	63	679	92093	8.73E-06	0.80139	9.97E-06	0.81603
		12	67	722	99428	8.18E-06	0.80219	9.05E-06	0.82099
		24	89	889	139590	8.55E-06	0.78029	7.70E-06	0.82166
	50	0	57	225	61237	1.41E-05	0.78084	6.81E-06	0.85138
		4	63	263	157840	8.02E-06	0.88339	9.23E-06	0.79092
		8	66	307	182210	2.57E-05	0.74914	8.68E-06	0.79293
		12	68	368	193800	3.46E-05	0.71701	8.36E-06	0.79488
		24	89	416	230930	4.21E-05	0.68892	7.61E-06	0.78479
	70	0	79	2465	83882	1.58E-05	0.73593	9.36E-06	0.86265
		4	95	1924	175400	1.60E-05	0.74821	9.88E-06	0.81108
		8	84	2183	217540	1.51E-05	0.74487	9.47E-06	0.81595
		12	83	2295	273790	1.65E-05	0.72846	9.07E-06	0.81578
		24	92	2777	312240	1.83E-05	0.70821	8.49E-06	0.82126
120	**0**	0	66	436	43206	2.32E-05	0.71821	5.18E-06	0.87944
	10	0	80	483	53248	1.72E-05	0.74696	1.16E-05	0.83680
	30	0	80	2767	59885	1.29E-05	0.74317	9.19E-06	0.86840
	50	0	80	4324	64662	1.11E-05	0.75446	7.72E-06	0.89592
	70	0	83	6437	81217	1.48E-05	0.74789	4.43E-06	0.96344

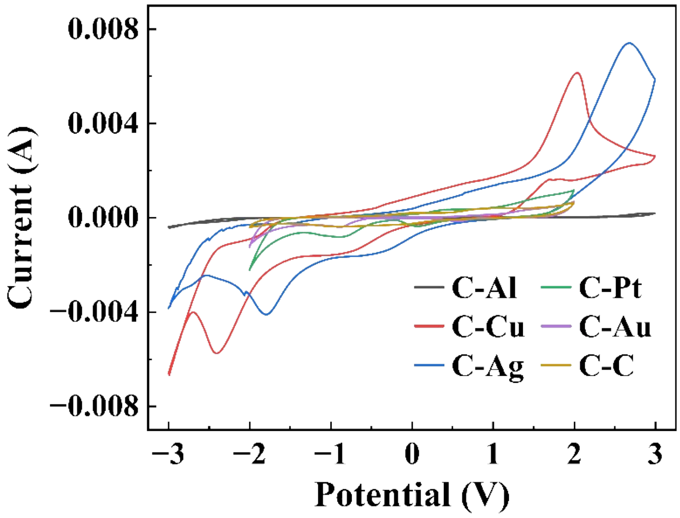

Figure S7. Cyclic voltammograms for different types of metallic electrodes in the solution of PVA/AA/PA obtained in a 2-electrode testing configuration with DLWc carbon as the counter electrode.

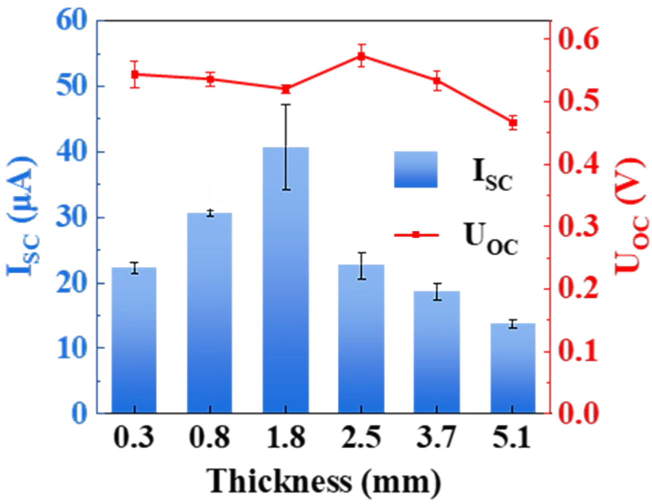

Figure S8. The effect of thickness of the hydrogel active material on Isc and Uoc for the DLWc-Hgel-MEG devices assembled from the PVA/PAA/PA hydrogels prepared from the PVA/AA/PA solution aged for 0.5 day and UV-exposure for 10 s without gel ageing treatment and tested at 85 RH%.

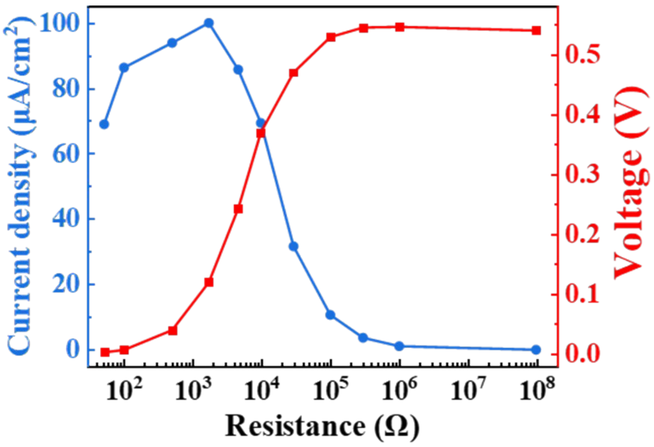

Figure S9. The current and voltage output of a selected DLWc-Hgel-MEG device (assembled using the PVA/PAA/PA hydrogel prepared from the PVA/AA/PA solution aged for 0.5 day and UV-exposure for 10 s without gel ageing treatment) to a resistor load at ambient environment (25 °C, 55 ± 3 RH%) for evaluating its power transfer capability.

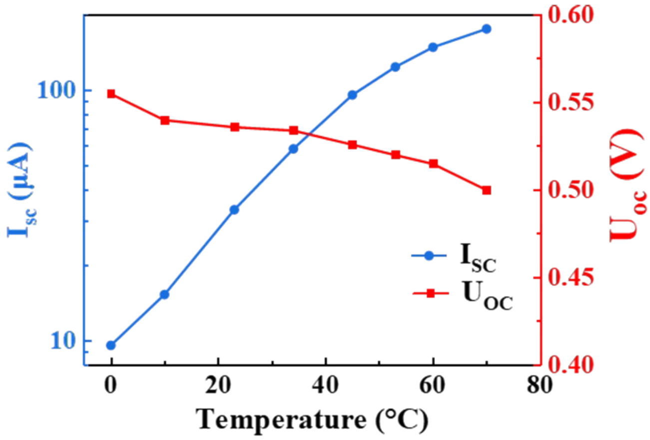

Figure S10. The current and voltage output of a selected DLWc-Hgel-MEG device (assembled using the PVA/PAA/PA hydrogel prepared from the PVA/AA/PA solution aged for 0.5 day and UV-exposure for 10 s without gel ageing treatment) evaluated in a temperature range of 0 – 70 °C at 85 ± 5% RH.