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Supporting information

Assessing the Potential of Biochar Derived from Sewage Sludge for Photoelectrode Fabrication: Methods, Mechanisms, and Conclusions

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Text 1: To explore the effect of different biochar dosing amounts on TC degradation, four gradients of 200mg, 300mg, 400mg, and 500mg were set for the specific biochar dosing levels. To explore the effect of different annealing temperatures on the effect of TC degradation, three temperature gradients of 250°C, 350°C, and 450°C were set to fabricate the electrodes.

Text 2：Samples were filtered through 0.22 μm cellulose acetate syringe membrane filters, and TC concentration was determined by (HPLC, Agilent 1260 series, USA) and Agilent TC-C18 column (4.6 × 250 mm, 5 μm). The mobile phase was a mixture of 80% formic acid and 20% acetonitrile. The flow rate and injection volumes were 0.5 mL/min and 20 μL, respectively. The wavelength of the detector was set to 354 nm. The retention time of TC was 3.5 min.

Text 3：Determination of the photodegradation intermediates of TC was carried out on an LC-MS system equipped with a 6460 HPLC (Agilent, USA) and an API 3000 mass analyzer. The HPLC column was a Kromasil C18 column (4.6 × 100 mm) from Agilent. 0.1% of formic acid aqueous solution and acetonitrile were used as mobile phases A and B, respectively. The eluent flow rate keeps at 0.45 mL/min. An injection volume of 10 μL was used in the analysis, and the column temperature at 302 K (30°C). Linear gradient elution as follows: The gradient solvent was as followed: A=90% (0 min), 10% (10 min), 10% (14 min), 90% (15 min), 90% (16 min). Max pressure limit: 1300 bar.

Text 4: The biochar electrode is used as the anode, the Platinum sheet electrode as the counter electrode, and Ag/AgCl as the reference electrode. The biochar electrode and the platinum sheet electrode were placed at an angle of 120°. The light-facing side of the biochar electrode is connected to the platinum sheet of the platinum sheet electrode clip. A bias voltage of 1.5V was applied after the open circuit voltage was stabilized. The lamp is turned on after the current is stabilized.

Text 5：The cost of the photoelectrode includes chemicals, equipment, and time. In this part, we considered the cost of chemical and electricity used for corresponding equipment. The chemicals used include foam nickel (\$3.79/0.06m^3), gelatin (\$7.58/500g), sodium dodecyl sulfate (\$3.94/500g), high-purity nitrogen gas (\$16.83/40L), high-purity argon gas (\$22.44/40L), ethanol (\$5.61/5L) and acetone (\$4.14/500ml). Each foam nickel can prepare 45 substrates. To prepare 4 photocathodes, the following are needed: 0.4 grams of gelatin, 10mg of sodium dodecyl sulfate, 0.045L nitrogen gas (0.03Mpa), and 1.071L argon gas (0.03Mpa); 40 ml of both ethanol and acetone each. In the end, the chemical cost of producing each photoelectrode is \$0.12. The power of the tube furnace is 1.2kw, the power of the freeze dryer is 0.85kw, and the cost of electricity is \$0.125 per Kw*h. To prepare 1 photocathode, the tube furnace consumes 0.02754 Kw*h of electricity, and the freeze dryer consumes 0.3699 Kw*h of electricity. Therefore, the electricity cost of producing each photoelectrode is \$0.25. Without taking into account equipment loss and labor costs, the production cost of each photocathode is only \$0.37. For a large synthesis, the average cost could be lower.

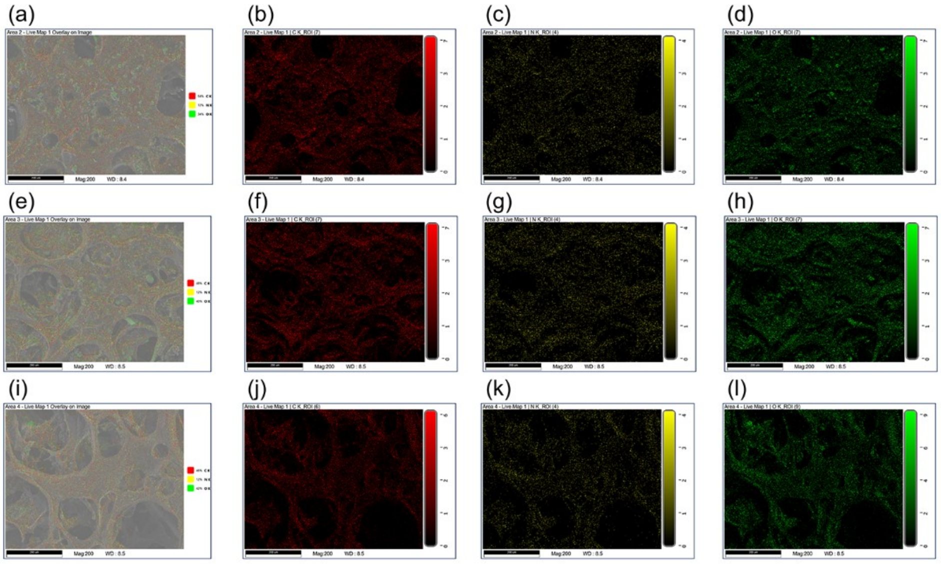


Fig. S 1 EDS elemental mapping of BCPE-700(a-d); BCPE-800(e-h) and BCPE-900(i-l).

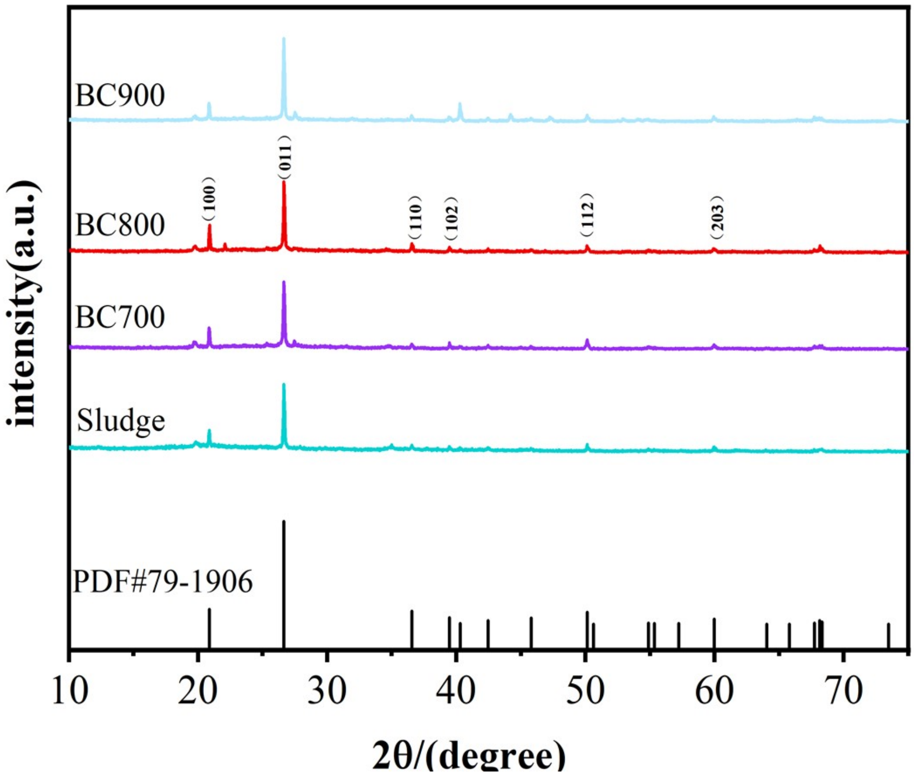


Fig. S2 XRD pattern of Sludge and BC.

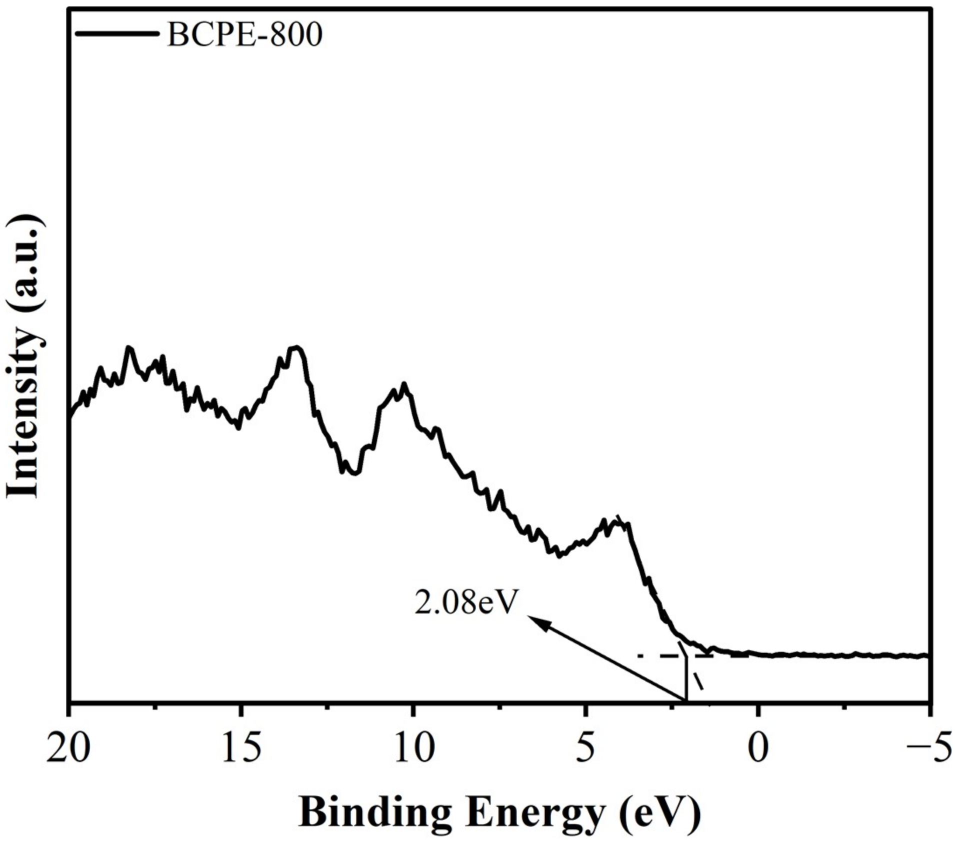


Fig. S3 VB-XPS spectroscopy of BCPE-800.

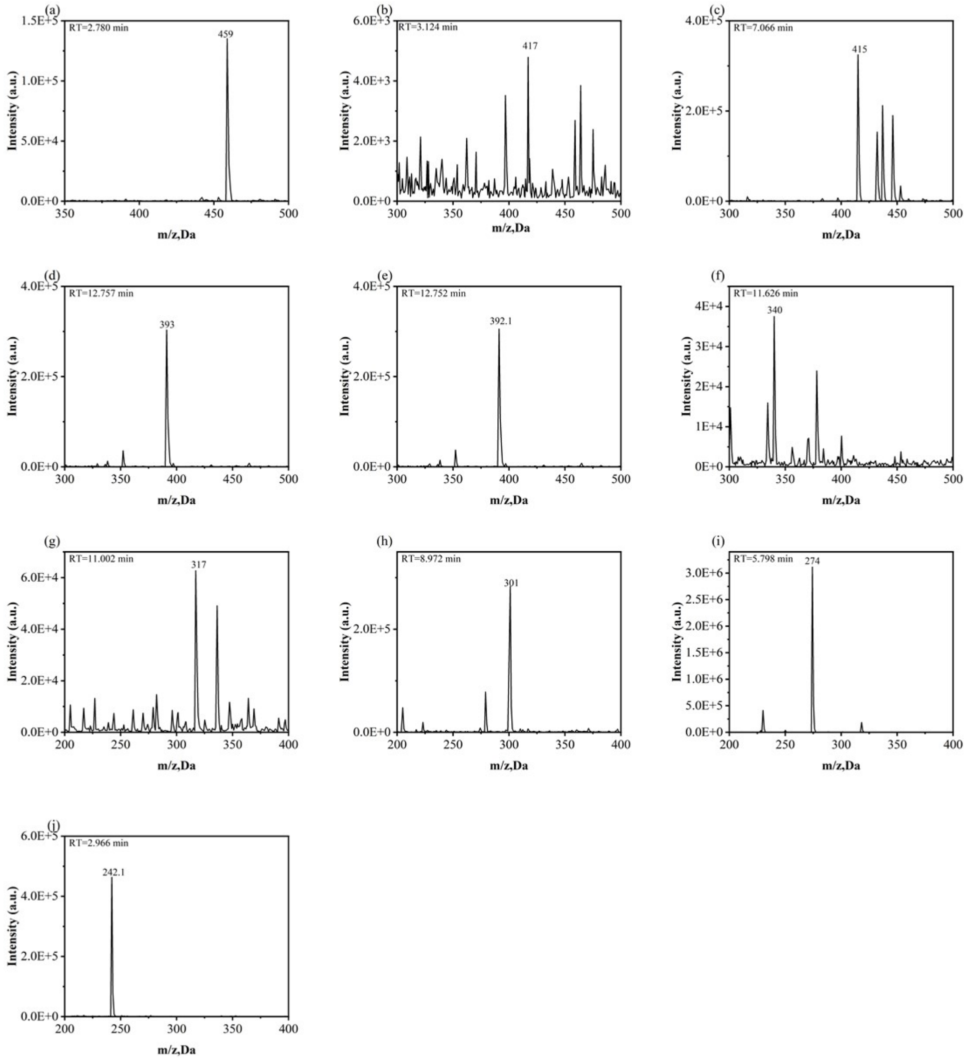


Fig. S4 LC-MS analysis of TC intermediates by BCPE-800.

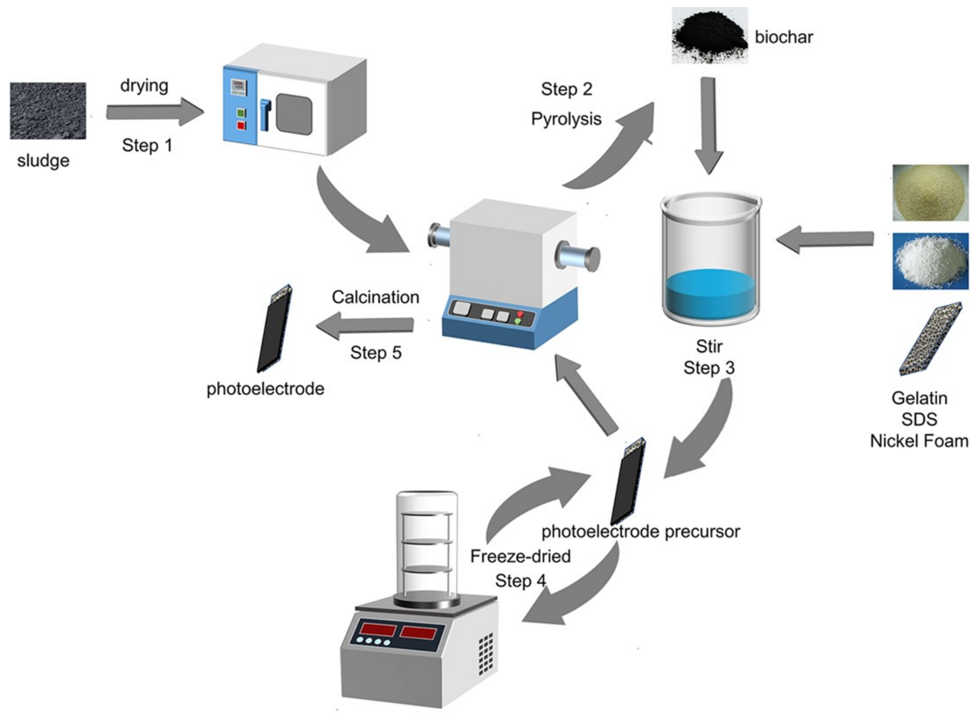


Fig. S5 Preparation process diagram of biochar photoelectrode.

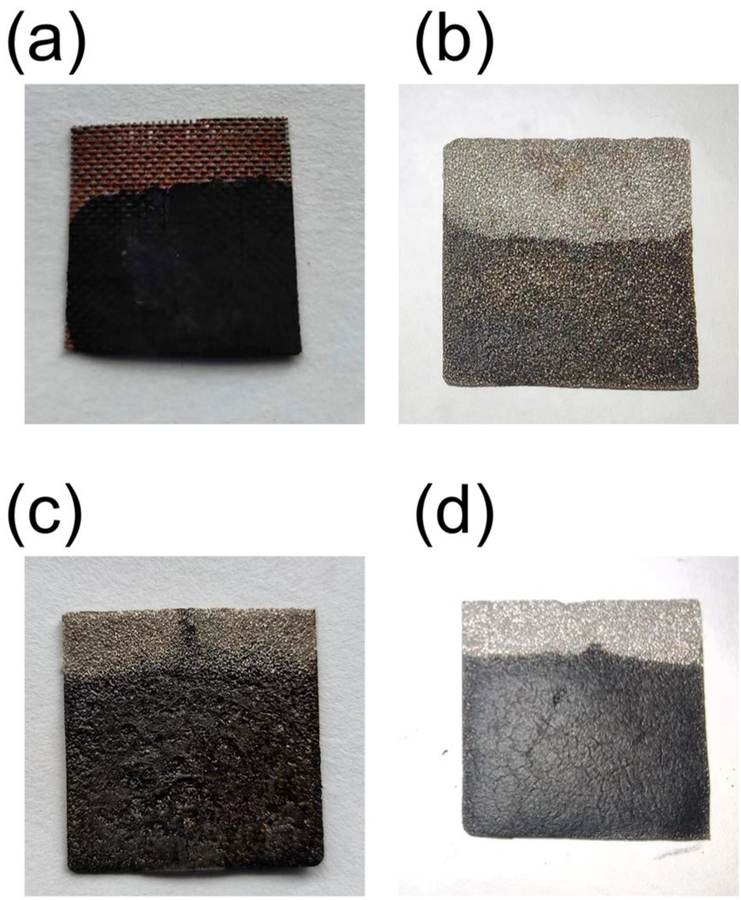


Fig. S6 Comparison of the morphology of photoelectrodes prepared by different methods.

Table S1The surface properties of SSBC with different pyrolysis temperatures.

Material	BET Surface Area (m^2/g)	Total pore volume (cm^3/g)
Sludge	16.27	0.05753
BC-700	67.53	0.1735
BC-800	83.40	0.1631
BC-900	141.4	0.2085

Table S2 The composition and ratio of each sample were measured by XPS.

element (%) Category	N	C	O	H	N/C	H/C	O/C
Sludge	3.89	26.78	26.56	4.21	0.15	0.16	0.99
BC-700	1.40	15.66	11.11	0.60	0.09	0.04	0.71
BC-800	0.83	15.07	7.74	0.46	0.06	0.03	0.51
BC-900	0.50	14.55	7.13	0.31	0.03	0.02	0.49
Gelatin	16.62	52.65	26.01	5.26	0.32	0.10	0.49
BCPE-700	9.11	33.31	18.71	2.82	0.27	0.08	0.56
BCPE-800	8.55	32.82	17.97	2.70	0.26	0.08	0.55
BCPE-900	8.56	33.27	15.95	2.73	0.26	0.08	0.48

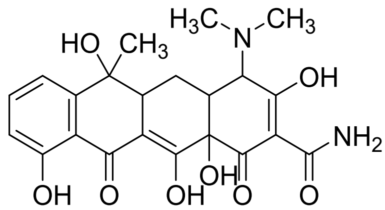
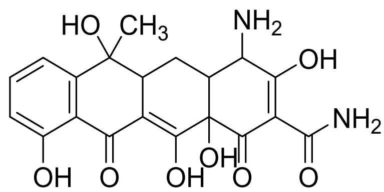
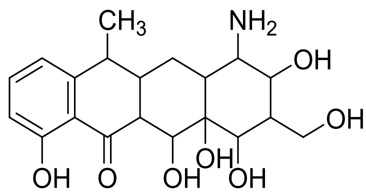
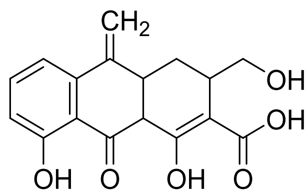
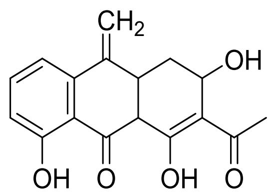
Table S3 Variation of TOC with degradation time.

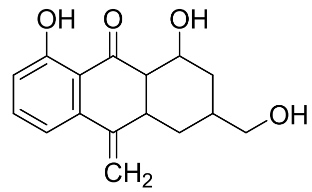
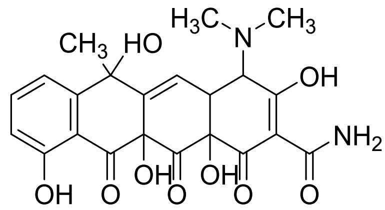
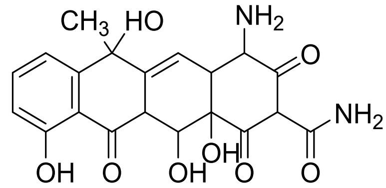
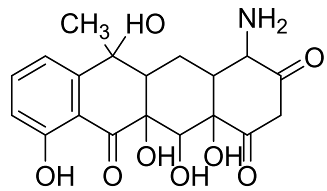
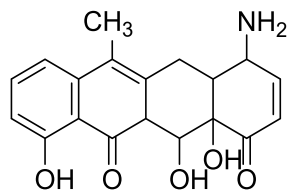
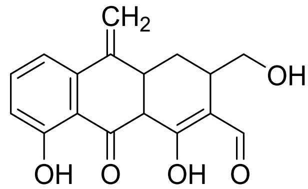
Time (min)	0	15	30	45	60
TOC (mg/L)	8.962	9.978	2.410	1.611	1.715
Efficiency (%)	0.00	11.34	73.11	82.02	80.86

Table S4 The quality parameters of tap water, river water and medical wastewater.

Parameters	Tap water	River water	Medical wastewater
pH	7.13	7.67	7.72
TOC	0.603 mg•L^{-1}	22.61 mg•L^{-1}	64.23 mg•L^{-1}

Table S5 Information and proposed structure of the degradation intermediates from TC.

Products	Molecular Formula	m/z	Proposed Structure
TC	$C_{22}H_{24}N_2O_8$	445	
P1	$C_{20}H_{20}N_2O_8$	417	
P2	$C_{20}H_{27}NO_7$	393	
P3	$C_{17}H_{16}O_6$	317	
P4	$C_{17}H_{16}O_5$	301	

P5	$C_{16}H_{18}O_4$	274	
P6	$C_{22}H_{22}N_2O_9$	459	
P7	$C_{20}H_{20}N_2O_8$	415	
P8	$C_{19}H_{21}N_1O_8$	392.1	
P9	$C_{19}H_{19}NO_5$	340	
P10	$C_{16}H_{15}NO_5$	301	
P11	$C_{12}H_{19}NO_4$	242.1