

Supplementary Information

1 Experimental

Text S1

To obtain acid-treated CNT, 15 g of CNT were first immersed in 300 mL of a concentrated $\text{HNO}_3/\text{H}_2\text{SO}_4$ mixture (volume ratio 1:3). The mixture was sonicated at room temperature for 30 minutes and then transferred to a flask, where it was maintained at 120°C for another 30 min. Afterwards, the CNT were thoroughly rinsed with deionized water until the rinse reached neutral pH, and finally vacuum-dried for 24 hours.

Text S2

For the C1P2 membrane, the current densities were -0.00656 A/cm^2 for glucose, -0.05331 A/cm^2 for HA, and -0.05994 A/cm^2 for BSA. For the C1P1 membrane, the current densities were -0.00842 A/cm^2 for glucose, -0.05032 A/cm^2 for HA, and -0.00726 A/cm^2 for BSA. For the C2P1 membrane, the current densities were -0.00662 A/cm^2 for glucose, -0.05994 A/cm^2 for HA, and -0.05951 A/cm^2 for BSA. The area of the working electrode was 1.68 cm^2 .

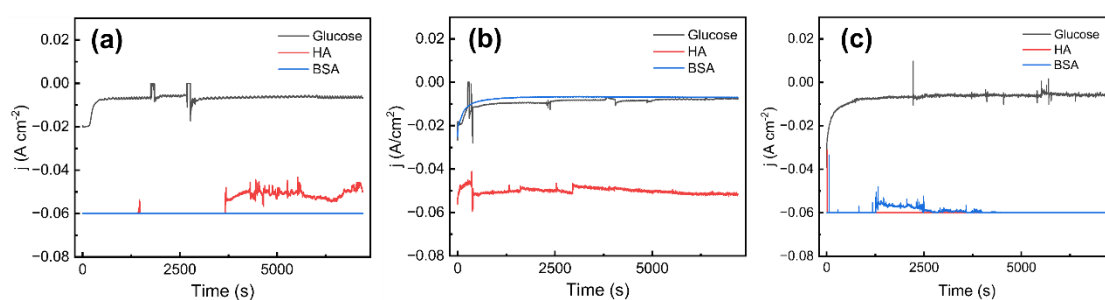


Fig. S1 The variations in the current density of (a) C1P2, (b) C1P1, and (c) C2P1 membranes over a degradation period of 7200 s. The black, red, and blue curves represent the glucose solution, HA solution, and BSA solution, respectively.

Tab. S1 Reagents and specifications for material preparation.

Chemical Name	Specification / Purity	Main Function	Supplier
Aniline (C ₆ H ₇ N)	Purity: ≥99.5% (AR)	Monomer for polymerization	Shanghai Aladdin, China
Ammonium persulfate ((NH ₄) ₂ S ₂ O ₈)	Purity: ≥95%	Oxidizing agent	Shanghai Aladdin, China
Potassium hydroxide (KOH)	Purity: ≥90%	pH adjustment	Shanghai Aladdin, China
Carbon nanotubes (CNTs)	Purity: >95%	Catalyst support	Shanghai Aladdin, China
Hydrofluoric acid (HF)	Concentration: 40%	Etching agent	Shanghai Aladdin, China
Sodium sulfate (Na ₂ SO ₄)	Purity: 99%	Background electrolyte	Shanghai Aladdin, China
D-(+)-Glucose (C ₆ H ₁₂ O ₆)	Purity: 90%	Model small organic molecule	Shanghai Aladdin, China
Humic acid (HA)	Purity: 99%	Model humic substance	Shanghai Aladdin, China
Bovine Serum Albumin (BSA)	Purity: 90%	Model protein	Shanghai Aladdin, China
Polyvinyl butyral (PVB)	Commercial grade	Binder	Sinopharm, China
N, N-dimethylformamide (DMF) (HCON(CH ₃) ₂)	Purity: 99.5%	Solvent	Nanjing Reagent, China
Sulfuric acid (H ₂ SO ₄)	Concentration: 98%	Acid treatment, pH adjustment	Nanjing Reagent, China
Nitric acid (HNO ₃)	Concentration: 99.8%	Acid treatment	Nanjing Reagent, China
Ultra-pure water	Resistivity: 18.2 MΩ·cm	Solvent for all experiments	Lab purification system