Uncovering interfacial electron transfer kinetics of WO3 biophotoelectrodes for food waste treatment

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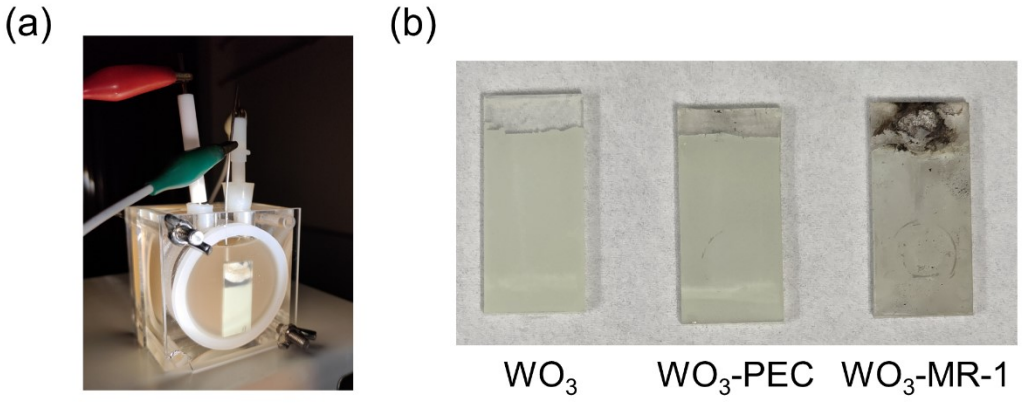

Figure S1. (a) Assembled S-MPEC chambers WO_3 as the working electrodes. (b) Photo of WO_3 and WO_3 after PEC measurement, and WO_3-MR-1 photoelectrode.

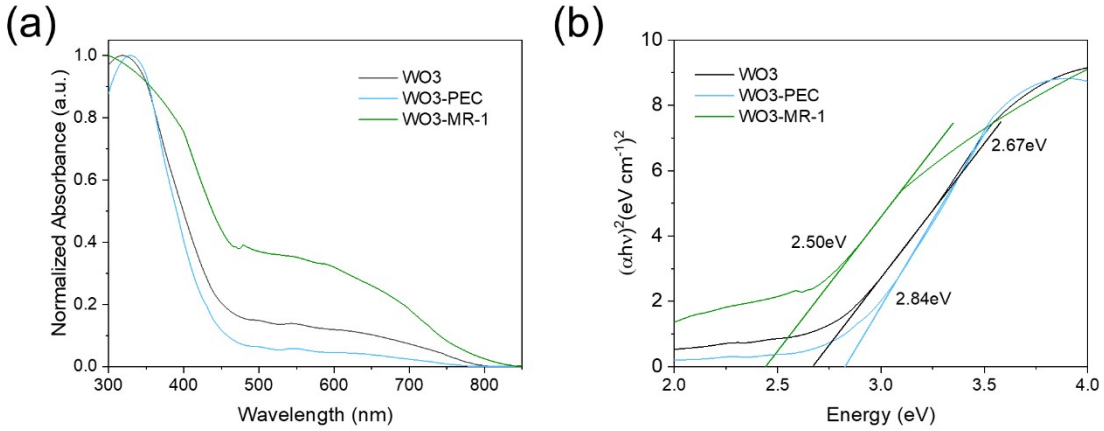

Figure S2. (a) UV-Vis diffuse reflectance spectrum and (b) Tauc plot of WO_3 and WO_3 after PEC measurement, and WO_3-MR-1.

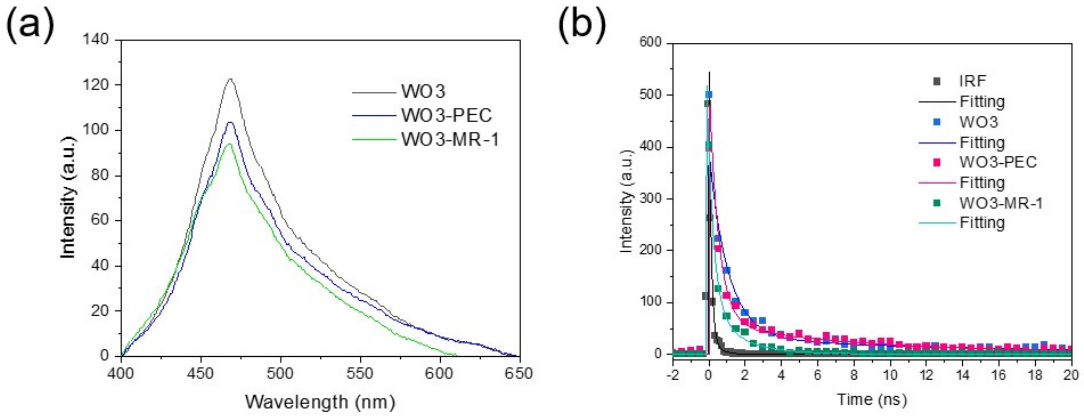

Figure S3. (a) Photoluminescence spectrum under excitation of 375nm and (b) Time-resolved photoluminescence spectra monitored at 470nm with 375 nm laser excitation.

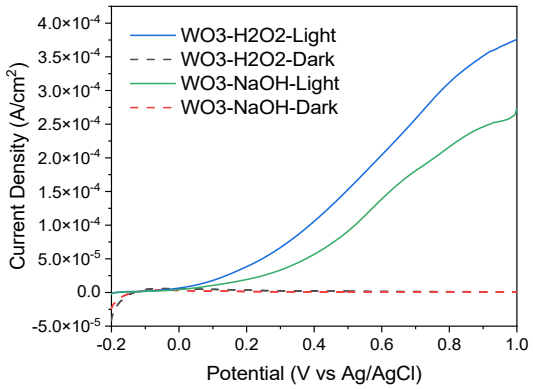

Figure S4. Linear sweep voltammetry curve of the WO_3 photoanodes in 1M NaOH with 100mM H_2O_2 as hole scavenger under 100 mW cm^{-2} irradiation.

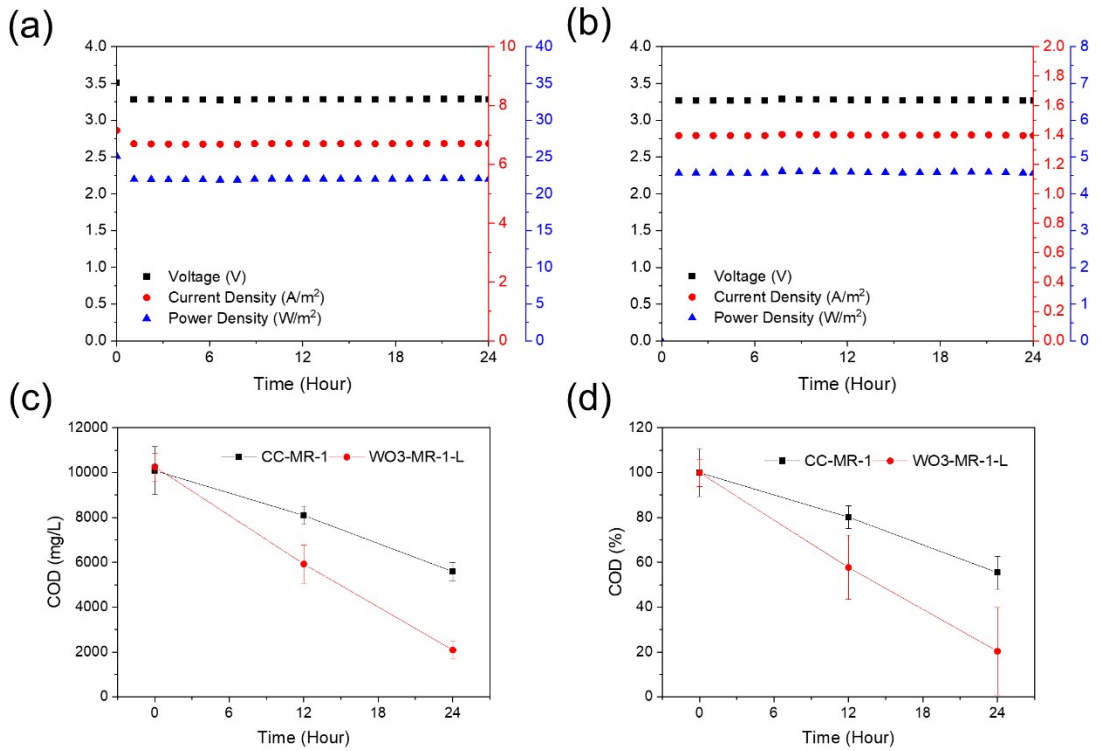

Figure S5. Voltage (black squares), current density (red circles), and power density (blue triangles) over a duration of 24 hours for PV-S-MPEC using (a) WO_3-MR-1 bioanode and (b) CC-MR-1 bioanode . (c) COD in mg/L and (d) COD percentage over a duration of 24 hours for PV-S-MPEC using CC-MR-1 bioanode (black squares) and WO_3-MR-1 bioanode (red circles).

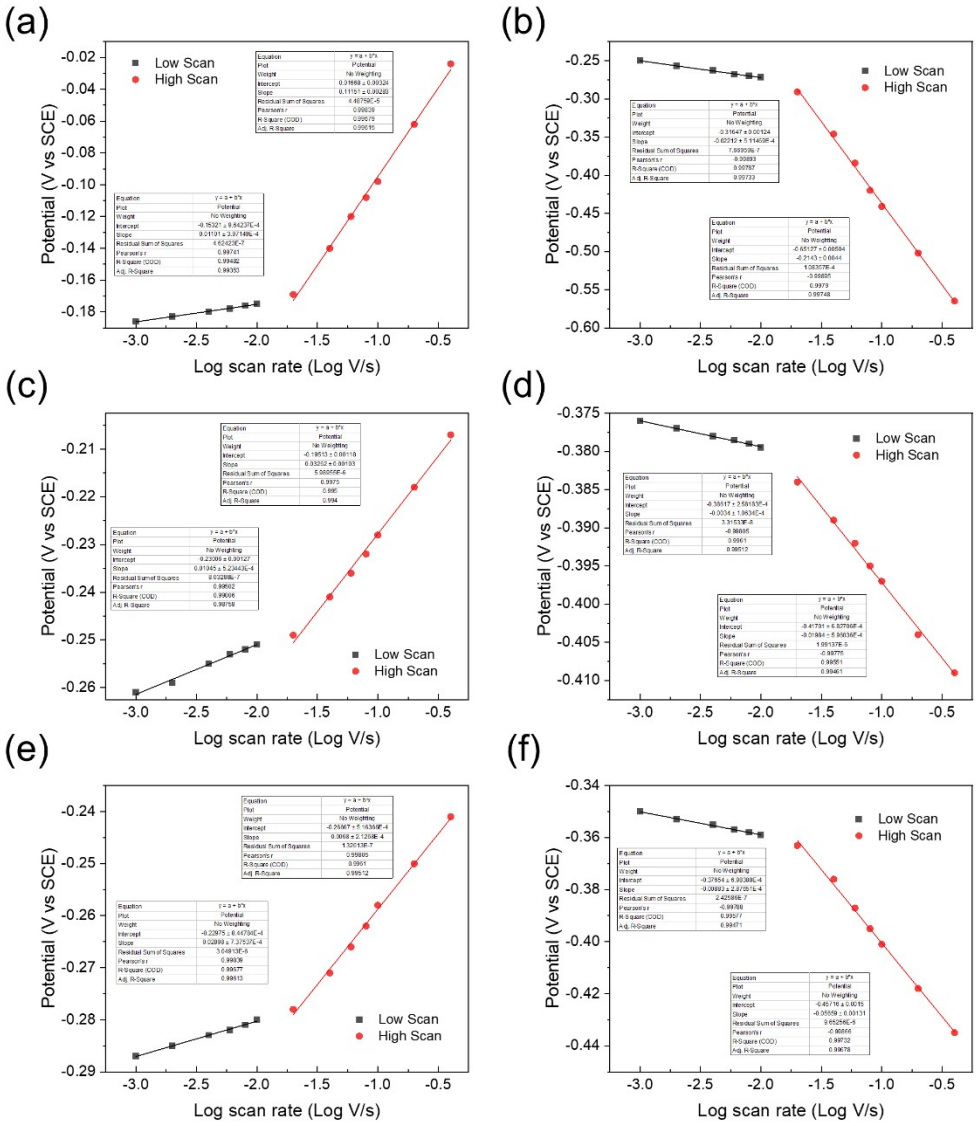

Figure S6. The plot of E_p against the log of scan rate at low and high scan rates of oxidation reaction using (a) CC-MR-1, (c) WO_3 and (e) WO_3-MR-1, as well as reduction reaction using (b) CC-MR-1, (d) WO_3 and (f) WO_3-MR-1 to determine of critical scan rate (V_c).

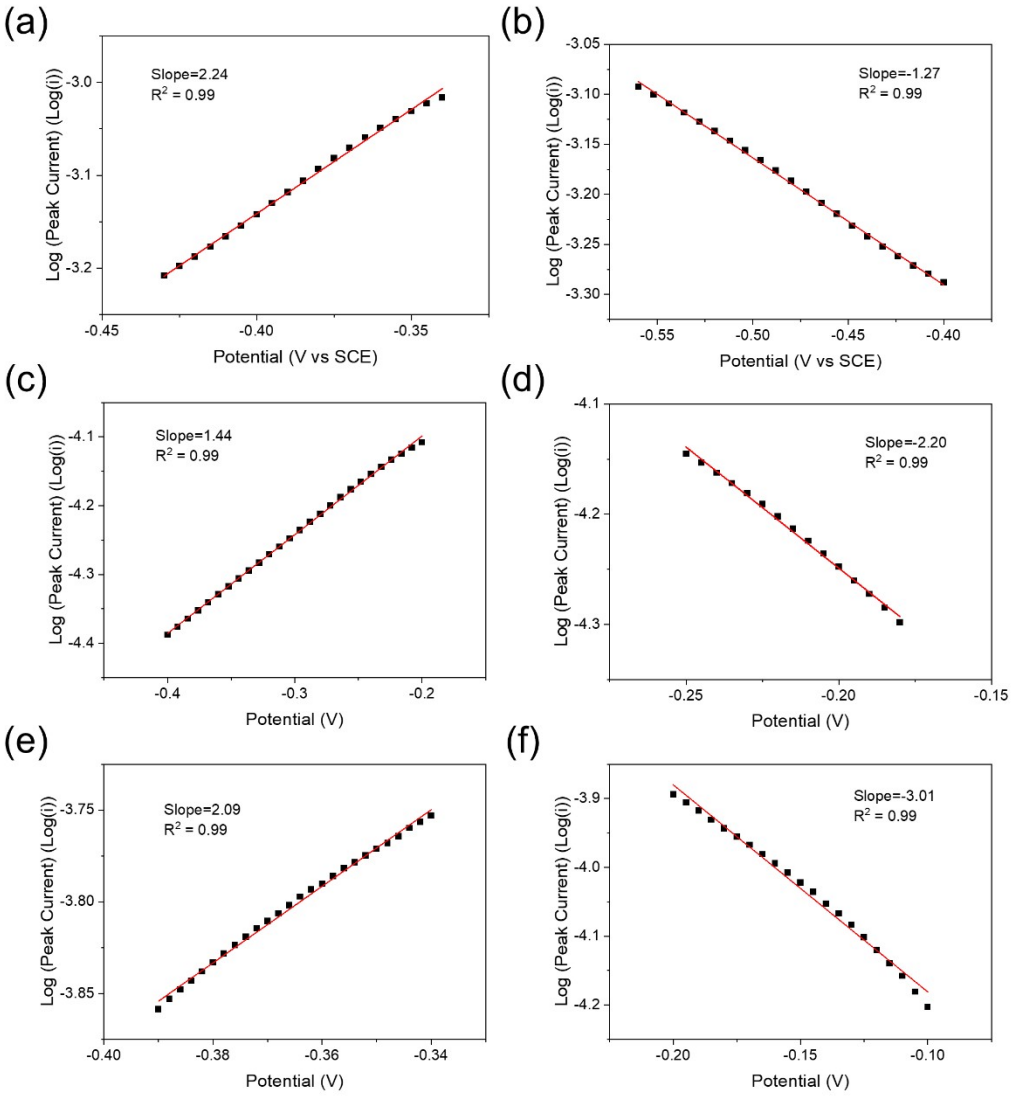

Figure S7. Tafel plot of the oxidation peak of (a) CC-MR-1, (c) WO_3 and (e) WO_3-MR-1 and the reduction peak of (b) CC-MR-1, (d) WO_3 and (f) WO_3-MR-1 at scan rate 100mV/s.

Table S1. The Chemical Oxygen Demand (COD) in mg/L of CC-MR-1, WO_3, WO_3-MR-1 (dark condition), and WO_3-MR-1 (irradiated condition) at T0 (0hr), T12 (12hrs), and T24 (24 hrs) under the external bias of 0.8V.

	CC-MR-1	**WO_3**	**WO_3-MR-1 (Light)**	**WO_3-MR-1 (Dark)**
T0 (mg/L)	12,490	14,173	12,390	13,207
T12 (mg/L)	11,623	13,140	10,523	11,923
T24 (mg/L)	10,623	12,523	8,523	11,140
COD removal (mg/L)	1,811	1,650	3,867	2,067

Table S2. The Chemical Oxygen Demand (COD) in mg/L of PV-S-MPEC using CC-MR-1, WO_3, WO_3-MR-1 (dark condition), and WO_3-MR-1 (irradiated condition) at T0 (0hr), T12 (12hrs), and T24 (24 hrs) under the 3.5V silicon photovoltaic (SiPV) applied bias.

	CC-MR-1	**WO_3-MR-1 (Light)**
T0 (mg/L)	10,090	10,257
T12 (mg/L)	8,090	5,923
T24 (mg/L)	5,590	2,090
COD removal (mg/L)	**4,500**	**8,167**

Table S3. Fitted parameters extracted from the Nyquist plots of all prepared sample electrodes.

	Carbon Cloth	**Bare WO_3**	**WO_3-MR-1**
Rs	12.27	13.72	8.637
CPE1-Anode-T	0.0784	0.00105	0.00101
CPE1-Anode-P	0.889	0.752	0.841
Ra	328.1	4373	4901
CPE1-Cathode-T	5.97×10^{-5}	3.47×10^{-4}	1.46×10^{-4}
CPE1- Cathode -P	0.695	0.459	0.523
Rc	5.28	82.1	39.9

Table S4. PL decay kinetics of all as-prepared samples.

Samples	τ_1/ns (a_1)	τ_2/μs (a_2)	$<\tau>^{a)}$/ns	c^2
WO_3	1.043 (91.35%)	10.66 (8.65%)	1.875	0.976
WO_3-PEC	0.531 (87.89%)	7.824 (12.11%)	1.414	0.814
WO_3-MR-1	0.361 (82.06%)	1.700 (17.94 %)	0.601	0.750

a) $\langle\tau\rangle=\sum_i \alpha_i \tau_i$

Calculation of daily food waste removal:

Food waste weight: 1000 g

Glucose concentration in hydrolysate based on 1 kg food waste: 98 g/L

COD Reduction in PV-S-MPEC using CC-MR-1 bioanode

COD removal:

COD removal = $\text{Initial}_{\text{COD}} - \text{Final}_{\text{COD}}$

COD removal = 10,090 mg/L−5,590 mg/L=4,500 mg/L

Removal Rate: 4,500 mg/L per day

Daily Food waste removal = 4.5 g/L/day ÷ 98 g/L × 1000g food waste

Daily food waste removal = 45.92 g food waste/day

COD Reduction in PV-S-MPEC using WO3-MR-1 bioanode

COD removal:

COD removal = $\text{Initial}_{\text{COD}} - \text{Final}_{\text{COD}}$

COD removal = 10,257 mg/L−2,090 mg/L=8,167 mg/L

Removal Rate: 8,167 mg/L per day

Daily Food waste removal = 8.2 g/L/day ÷ 98 g/L × 1000g food waste

Daily food waste removal = 83.67 g food waste/day