Electronic supplementary information for

“Hydrogen peroxide-producing electrochemical bandage controlled by a wearable potentiostat for treatment of wound infections”

Abdelrhman Mohamed[1], MD Monzurul Islam Anoy[1], Gretchen Tibbits[1], Yash S. Raval[2], Laure Flurin[2], Kerryl E. Greenwood-Quaintance[2], Robin Patel[2,3] and Haluk Beyenal[1,*]

[1]The Gene and Linda Voiland School of Chemical Engineering and Bioengineering, Pullman, WA, USA

[2]Division of Clinical Microbiology, Mayo Clinic, Rochester, MN, USA

[3]Division of Infectious Diseases, Mayo Clinic, Rochester, MN, USA

[*]**Correspondence:**

Haluk Beyenal

P.O. Box 646515

Wegner Hall, Room 305

The Gene and Linda Voiland School of Chemical Engineering and Bioengineering

Washington State University

Pullman, WA 99164-6515

E-mail: beyenal@wsu.edu

S1. Wearable potentiostat design

The wearable potentiostat is designed to be lightweight and battery operated to enable its use in small animal models. Schematics of the potentiostat circuit are shown in **Figure S1**A. The potential of the working electrode (WE) is set using a potential control amplifier (PCA) relative to the reference electrode (RE) using an input voltage ($v1$). The current resulting from the polarization of the WE is measured using a trans-impedance amplifier (TIA) with a gain resistor (R) connected in parallel to a capacitor (C). An equivalent current magnitude passes through the counter electrode (CE) which is connected to the output terminal of a PCA. A two op-amp chip is used for a PCA and TIA (LMC6482, Texas Instruments, Dallas, TX). In this work, a 100 Ω resistor and 10 μF capacitor are used for R and C, respectively. The electronic circuit is assembled on a printed circuit board using a flexible lightweight polyimide substrate to minimize its weight (Felios F775, Panasonic, Kadoma, Osaka, Japan). A quick connect terminal is used to connect the potentiostat to the e-bandage [SM03B-SRSS-TB(LF)(SN), JST Sales America Inc., Waukegan, IL]. A photograph of the printed circuit board is shown in Figure 4C and Figure S1B. The potentiostat is powered using a 3V lithium ion button cell (CR1225, Panasonic, Kadoma, Osaka, Japan), housed in a battery holder soldered to the printed circuit board (3001, Keystone Electronics, New Hyde Park, NY). The 3V battery is used to power the PCA and the TIA. A 2.5V regulated voltage is obtained using a low dropout voltage regulator (TPS71525, Texas Instruments, Dallas, TX). Two two-resistor voltage dividers are used to control the value of $v1$ and $v2$ at 0.8 V and 0.115 V, respectively. Accordingly, the WE is controlled at -0.685 V relative to the RE (-0.6 $V_{Ag/AgCl}$), which is suitable for the continuous generation of H_2O_2 (Sultana et al., 2015). The potentiostat is automatically turned on when the battery is inserted.

In select experiments, an 11-bit multichannel data acquisition module (USB-1208FS, Measurement Computing, Norton, MA) was used to record the potentials of the working and counter electrodes, as well the working electrode current (measured as the TIA output: *i*R). The data acquisition module is configured to measure a differential analog input of ±5V with a data acquisition rate of 1 Hz. The resolution at this configuration is 0.45 mV. Total current consumed during potentiostat operation was measured using a Keithley 6517B electrometer (Tektronix, Beaverton, OR).

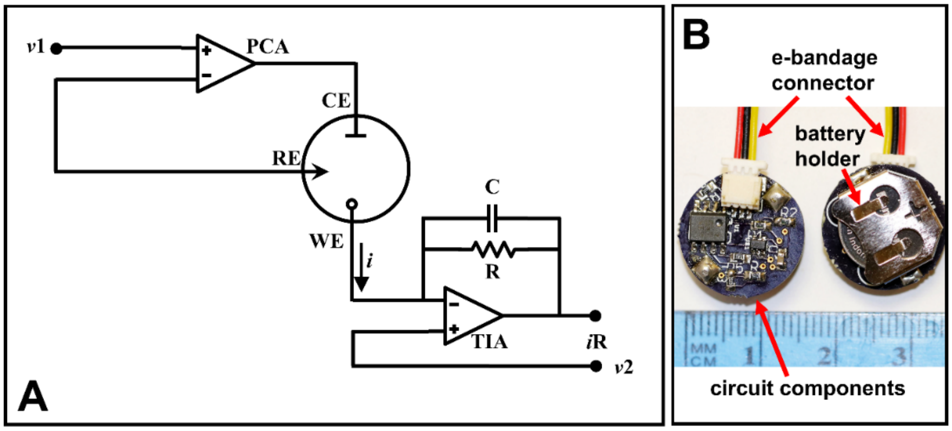

Figure S1. A) Schematic and B) photograph of the wearable potentiostat controlling the e-bandage.

S2. Verification of custom potentiostat operation

The performance of the potentiostat circuit was verified using a dummy resistive cell. The dummy cell is made by connecting two 10 kΩ resistors (1% precision) to the potentiostat's e-bandage quick-connect terminal. One resistor is connected between the counter and reference terminals, and the other between the working and reference electrode terminals. The dummy cell is used to verify that the potentiostat is operating as designed.

The goal of the dummy cell verification experiment was to verify that the potentiostat controls the working electrode potential at the set value of -0.685 V relative to the reference electrode. Because a resistive dummy cell is used, the current passing through the working electrode follows Ohm's law (current = voltage/resistance). The expected current for a 10 kΩ resistive load controlled at -0.685 V is -68.5 µA (-0.685 V/10 kΩ). The potentiostat was connected to a data acquisition module to record working and counter electrode potentials as well as working electrode and battery currents when connected to the dummy cell. The measured working electrode potential was -0.686 ± 0.003 V, and the working electrode measured current was -66.2 ± 1.3 µA (**Figure S2**A and S2C). Response time of the potentiostat was faster than the 1 s sampling time used in these measurements (Figure S2B). The measured values deviated from nominal values by -0.1 and 3.4% for applied potential and measured current, respectively. The error associated with the applied potential is likely due to the value of the resistors used in the voltage dividers used to set the values of $v1$ and $v2$. Error in measured current represents an output value of 0.2 mV, lower than the resolution of the data acquisition module (0.45 mV). Because the potentiostat passes an equal magnitude but opposite direction of current through the counter electrode, we expect the counter electrode potential to be 0.685 V. The measured counter electrode potential was 0.690 ± 0.004 V, which is within the expected range considering 1%

precision resistors were used in the dummy cell (Figure S2A). Overall, the results verify that the potentiostat adequately controlled the working electrode potential and provided the correct output for working electrode current. The total current consumed to operate the potentiostat and polarize the dummy cell was -168.0 ± 0.3 µA (Figure S2C). By subtracting current passing through the working electrode, we deduced that -101.8 ± 1.3 µA was required to operate the potentiostat circuit, which was constant throughout the duration of the experiment (Figure S2D). For simplicity, we show short-term (less than 4 h) operation data for experiments using the dummy cell. Because a constant resistive load is used, we expect the potential and current to remain constant for longer experimental durations.

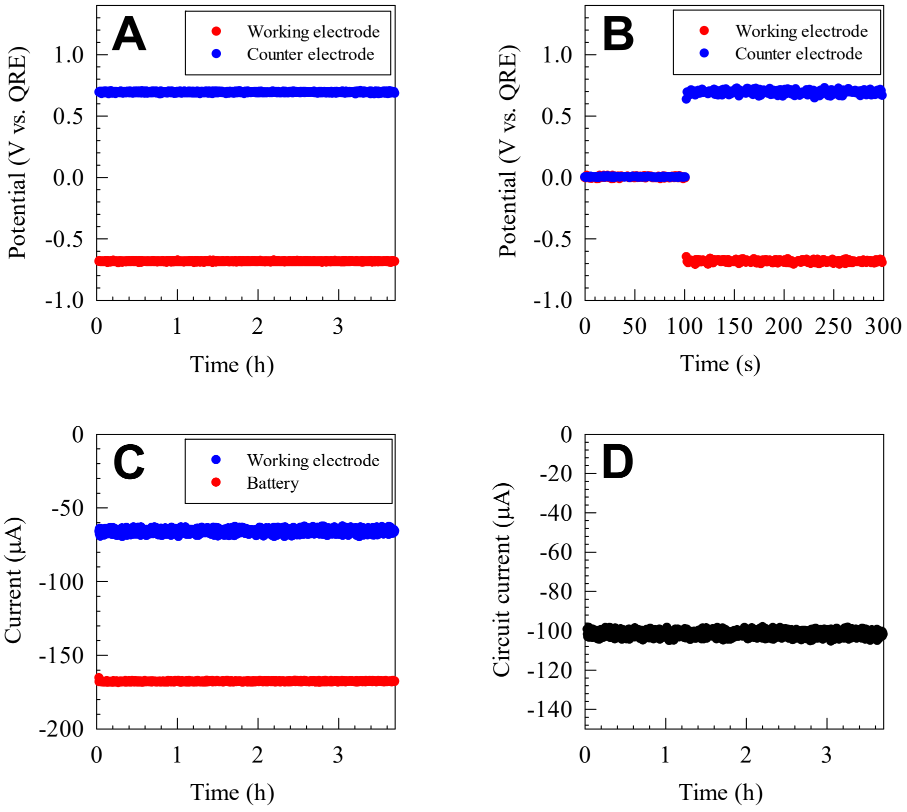

Figure S2. Verification of potentiostat operation using a resistive dummy cell. Working and counter electrode potentials for 3.7 h (A) and 300 s (B) of operation. C) Current delivered through the working electrode and total current consumed through the system. D) Current required to operate the potentiostat circuit.

References:

Sultana, S. T., Atci, E., Babauta, J. T., Falghoush, A. M., Snekvik, K. R., Call, D. R., & Beyenal, H. (2015). Electrochemical scaffold generates localized, low concentration of hydrogen peroxide that inhibits bacterial pathogens and biofilms. *Scientific Reports, 5*(1), 14908. doi:10.1038/srep14908