Electronic Supplementary Material (ESI) for Physical Chemistry Chemical Physics.

Flow dependent performance of microfluidic microbial fuel cells

Daniele Vigolo, Talal T. Al-Housseiny, Yi Shen, Fiyinfoluwa O. Akinlawon, Saif T. Al-Housseiny, Ronald K. Hobson, Amaresh Sahu, Katherine I. Bedkowski, Thomas J. DiChristina, and Howard A. Stone

Electronic Supplementary Material

Contents:

Supplementary discussion and supplementary figures:

- ***Polarization curve***
- ***Steady state at different flow rates***
- ***Microelectronic devices powered by MFCs***

Polarization curve

The polarization curve presented in Fig. 7 of the paper is obtained by varying the resistance of three mature MFCs and evaluating the power generated by the MFC for each different load.

In Fig. S1 we present the complete data. At time $t=0$ the three MFCs were inoculated with *S. oneidensis MR-1*. After 15 minutes the flow of anolyte and catholyte were started at 20 μL/min. After about 45, 90 and 140 hours the syringes of tryptic soy broth (TSB) medium and phosphate-buffered potassium ferricyanide catholyte solution ($K_3Fe(CN)_6$) were refilled. The refilling procedure corresponds to a dip in the voltage curve.

After reaching steady state, at 162.4 hours the resistors of each cell, initially equal to 100 kΩ for every MFC, were varied. The exact sequence is shown in Fig. S2.

After the change in resistance, R, the MFC was left to re-equilibrate for at least 3 hours and then the new steady state value was collected to generate the polarization curve. For each value of R a voltage drop, V, was measured. Then, by applying Ohm's law, the current, I, and the power, P, were evaluated as $I = V/R$ and $P = V^2/R$.

A summary of the values of voltage, V, current, I, and power, P, obtained using the above procedure is given in table 1.

R (ohm)	**V (mV)**	I (μA)	P (μW)
1222000	762	0.62	0.48
990000	757	0.76	0.58
470000	755	1.61	1.21
295000	738	2.50	1.85
198000	697	3.52	2.45
148000	659	4.45	2.93
100000	646	6.46	4.17
100000	647	6.47	4.18
75000	559	7.45	4.17
49000	469	9.57	4.49
20000	270	13.50	3.65
8130	133	16.36	2.18
9900	166	16.77	2.78
5000	88	17.60	1.55
2400	56	23.33	1.31
1000	25	25.00	0.63
550	17	30.91	0.53

Table 1: summary of the value of voltage, V, current, I, and power, P, obtained from the mature MFCs in the presence of different loads.

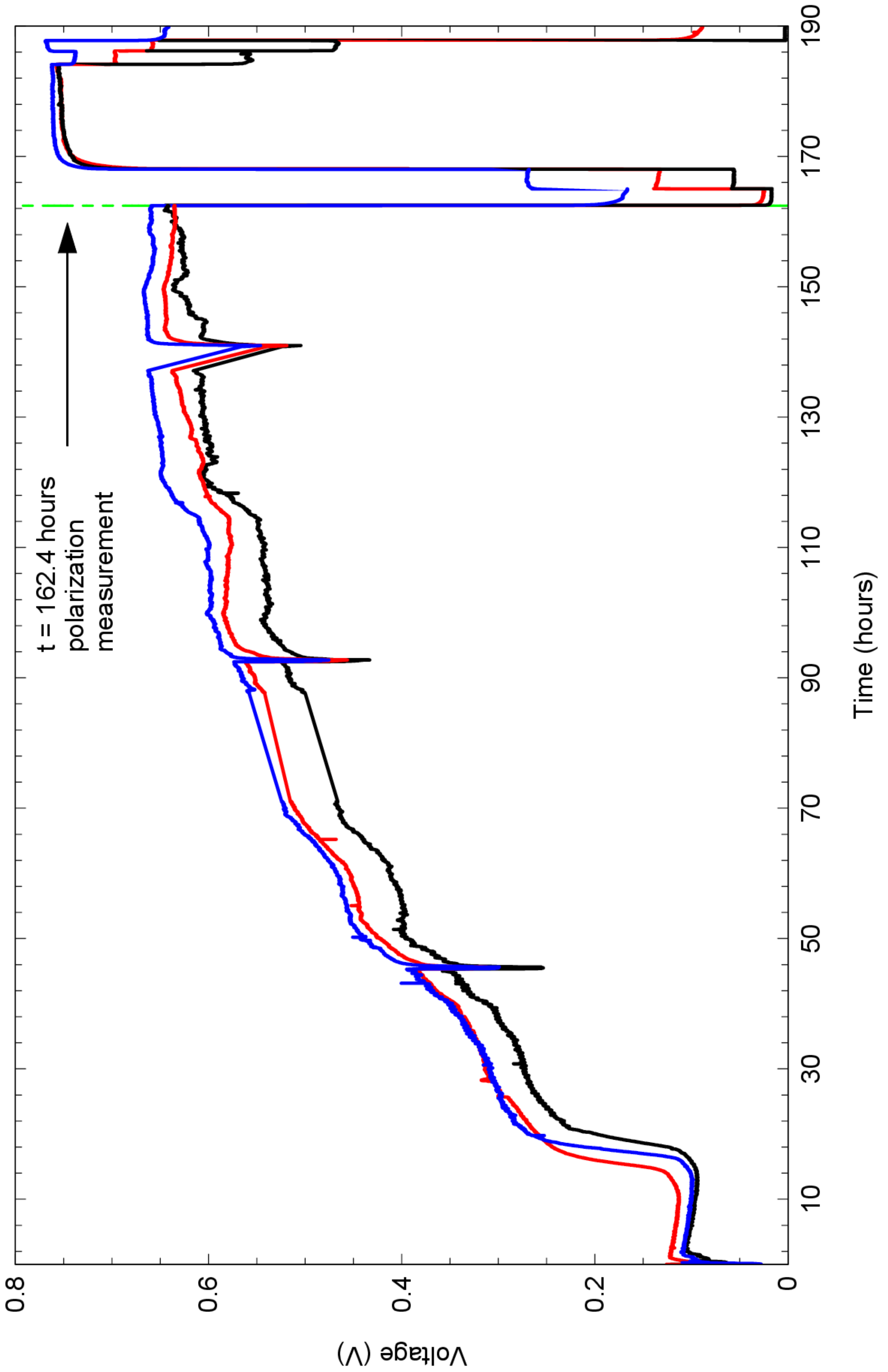

Fig. S1: Voltage versus time curves for three MFCs fed at a flow rate of 20 μL/min. Once the steady state is reached, at t=162.4 hours the load is changed in order to reconstruct the polarization curve (see Fig. S2).

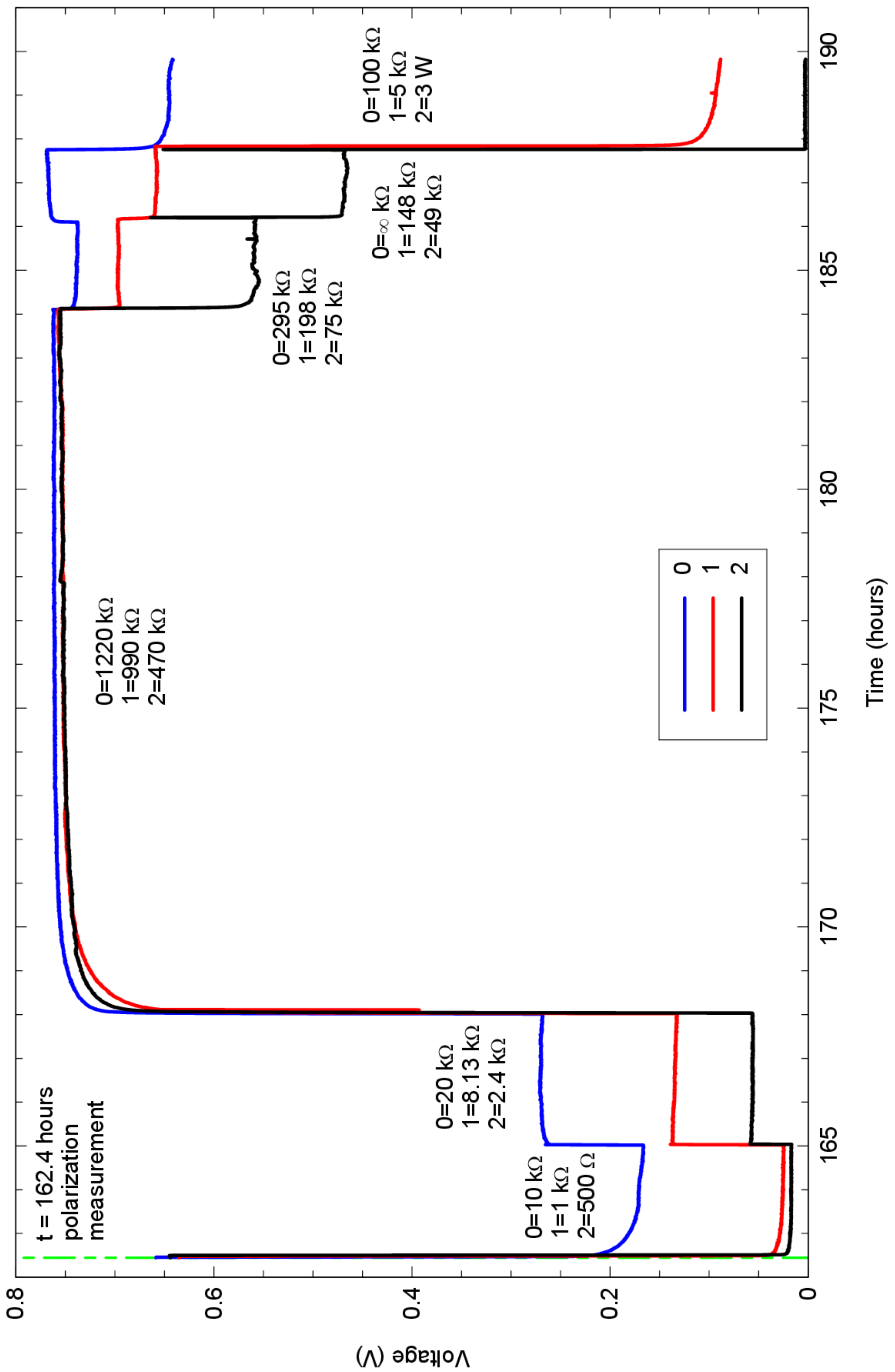

Fig. S2: Blow-up of the voltage vs. time curve shown in Fig. S1. At each step the three mature MFCs are connected to a different resistor and their voltage drop is evaluated after at least 3 hours, so that a new steady state is reached. The resistance of each load used is shown in the above image.

Steady state at different flow rates

In our experiments, after approximately 130-140 hours the voltage output of the MFC was roughly constant, with a 1-2% variation after 160 hours. After that, the MFC is considered to be operating at steady state.

Once the MFC reaches the steady state, we record the maximum value of the voltage output as the voltage value corresponding to that specific flow rate tested.

Four different experiments were conducted for each flow rate, in 4 different MFCs to ensure statistically significant variations.

As you can see in Fig. S3, the steady state is reached approximately around the same time for all flow rates. When the flow rate is faster, steady state is reached slightly faster as shown in Fig. S3 for the case of 30 μL/min.

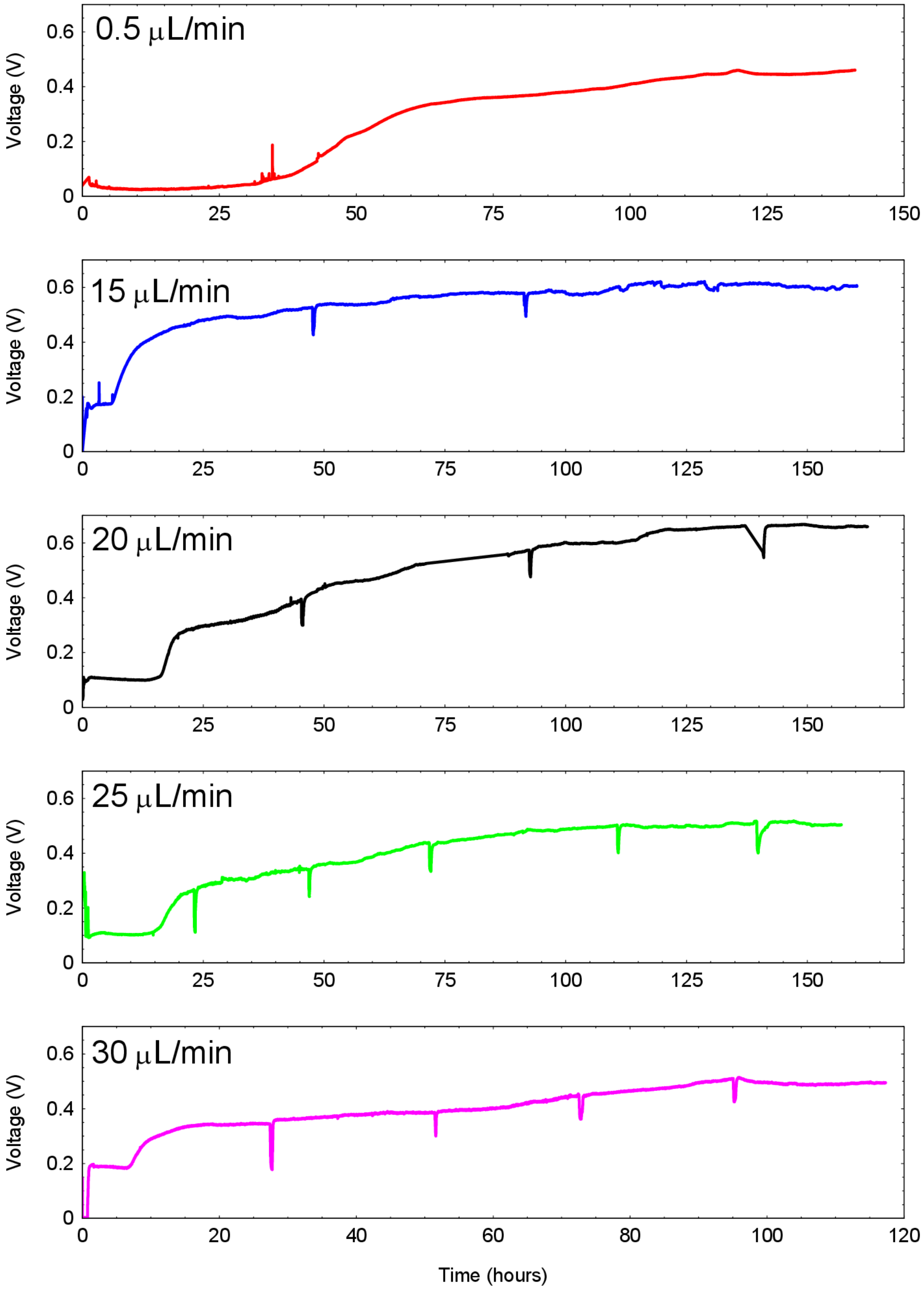

Fig. S3: Complete voltage output curve for different flow rates Q. It is clear that in all cases the steady state is reached at about 160 hours.

Microelectronic devices powered by MFCs

We use here multiple MFCs to power up small electronic devices. In particular, we connected 4 mature MFCs in series obtaining an open circuit voltage of about 2.6 V. Using this setup, we were able to power a stop- watch (see fig. S4 panel a) and to light up an LED (see fig. S4 panel b).

This simple application shows the feasibility to use our MFC design to actually operate simple devices. It would be possible to use our proposed design to power up for example sensors or small displays for diagnostics.

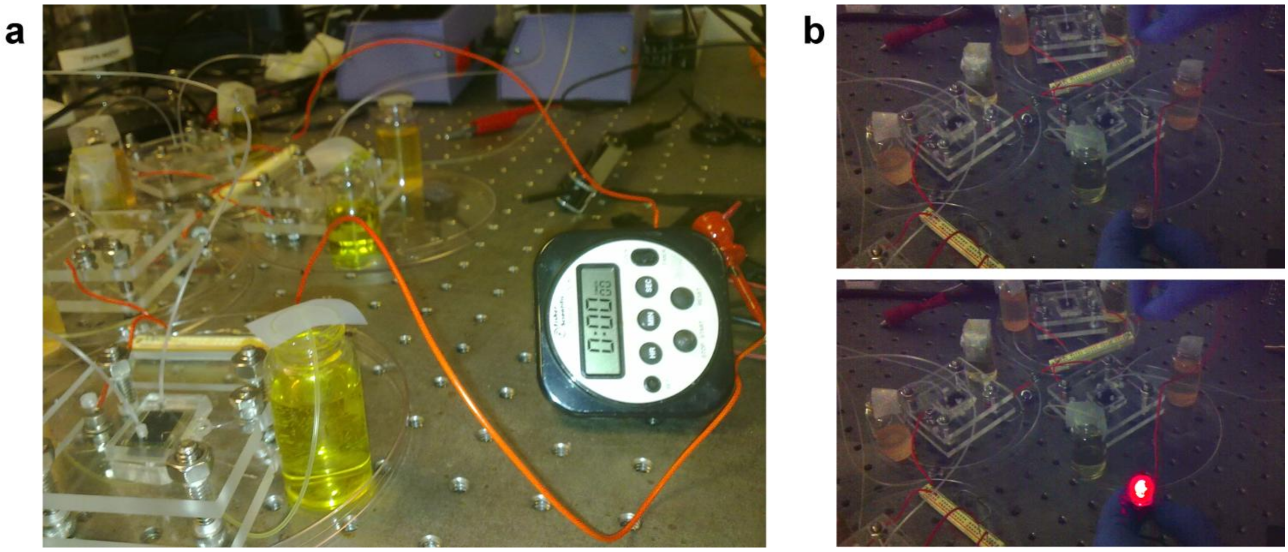

Fig. S4 Demonstration of practical capabilities of MFCs. Four MFCs are connected in series generating 2.6 V, enough to power up (a) a stopwatch, and (b) an LED.