† *Electronic Supplementary Information:*

DC-biased AC-electrokinetics: A Conductivity Gradient Driven Fluid Flow†

Wee Yang Ng,[a,b] Antonio Ramos,[c] Yee Cheong Lam,[b] I Putu Mahendra Wijaya[a,d] and Isabel Rodriguez*,[a]

[a]Institute of Materials Research and Engineering, Agency for Science, Technology and Research (A*STAR), 3 Research Link, Singapore 117602, Singapore
[b]School of Mechanical & Aerospace Engineering, Nanyang Technological University, Nanyang Avenue 50, Singapore 639798, Singapore
[c]Departamento de Electrónica y Electromagnetismo, Facultad de Física, Universidad de Sevilla, Reina Mercedes s/n, 41012 Sevilla, Spain
[d]Institut de Science et d'Ingénierie Supramoléculaires (ISIS), Université de Strasbourg, CNRS UMR 7006, 8 allée Gaspard Monge, 67083 Strasbourg Cedex, France

(1) Details on Experimental Setup

Figure S1(a) shows the experimental setup of the pH tracing experiment conducted. A DC power supply (GW Instek, PPE-3323) is used to provide the electrical signal. Device A is mounted onto an upright microscope (Olympus, BX51) with an epi-fluorescence source that is used to excite the fluorescent dye. A syringe pump (Harvard Apparatus, PicoPlus) is used to inject a Fluorescein solution into the microchannel. Images are captured using a CCD camera (Roper Scientific).

Figure S1(b) shows the experimental setup of the conductivity measurement conducted. The H^+ and OH^- streams were collected independently into two microtubes as shown in Figure S1(b)(i). Impedance measurement were conducted using an impedance analyzer (Agilent 4294A) as shown in Figure S1(b)(ii). Platinum electrodes were used for impedance measurements (Advent, Diameter = 0.25mm, purity 99.95%, PT543409) fixed by epoxy glue to have an exposed area l = 4 mm and a separation gap of ~1 mm

Figure S1(c) shows the experimental setup for cross-section flow imaging. A function generator (Instek, GFG-8216A) is used to provide the electrical signal and an amplifier (Thurlby Thandar Instruments, WA301 Wide Band Amplifier 30 V pk-pk) is used to amplify the voltage signal when necessary. The output voltage signal is monitored by an oscilloscope (Hewlett Packard, 54600B Oscilloscope 100 MHZ) which is also connected to the electrodes of Device B through a relay (Hamlin, HE3621A0510).

This relay acts as a switch for the device which is controlled via a custom written Labview program from a computer card (National Instruments, PCI 6723). Device B (loaded with microbeads) is mounted onto an upright microscope (Olympus, BX51). The fluorescent microbeads are excited from the epifluorescence source of the upright microscope. Images are captured using a CCD color video camera (Sony, DXC-390P) through a stereo-microscope (Olympus, SZ 11) which is positioned from the side using a stand (Olympus, SZ-STU2). A longpass filter (Edmund Optics, OG-570, 2" square, cutoff λ = 570±6 nm) is used to cutoff the excitation light and thus allowing the stereo-microscope to capture the emission light from the microbeads.

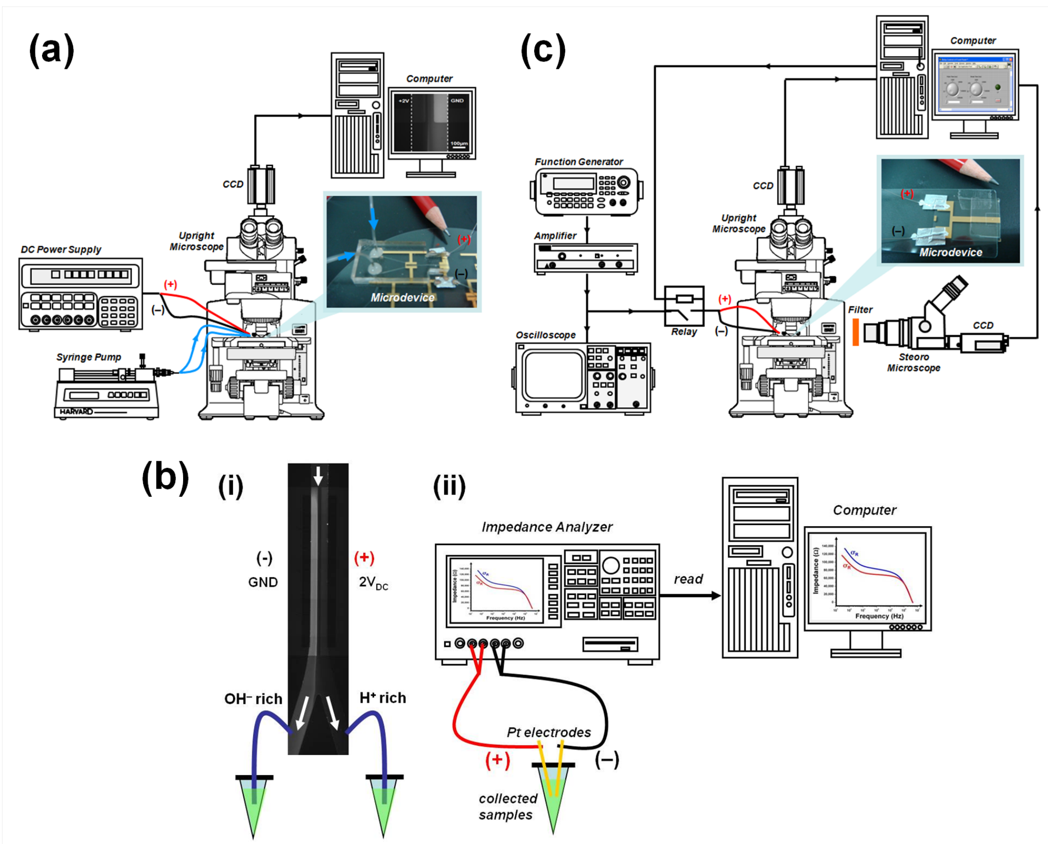

Figure S1. Experimental setup for (a) pH tracing, (b) conductivity measurement – (i) samples collection, (ii) impedance measurement, and (c) cross-section imaging.

(2) Impedance Data of the Collected H^+/OH^- Streams

Figure S2 shows the impedance plots for the collected acidic and basic streams injected at two flow rates (0.5 μL/min, 1.0 μL/min). In the six pairs of samples collected, the results consistently indicate that the OH^- stream had impedance lower than the H^+ stream. This in turn implies that the OH^- stream was more conductive than the H^+ stream. It should be noted that this method is extremely sensitive in detecting conductivity change since the impedance drop follows a power law decay with conductivity as shown in Figure 3(b).

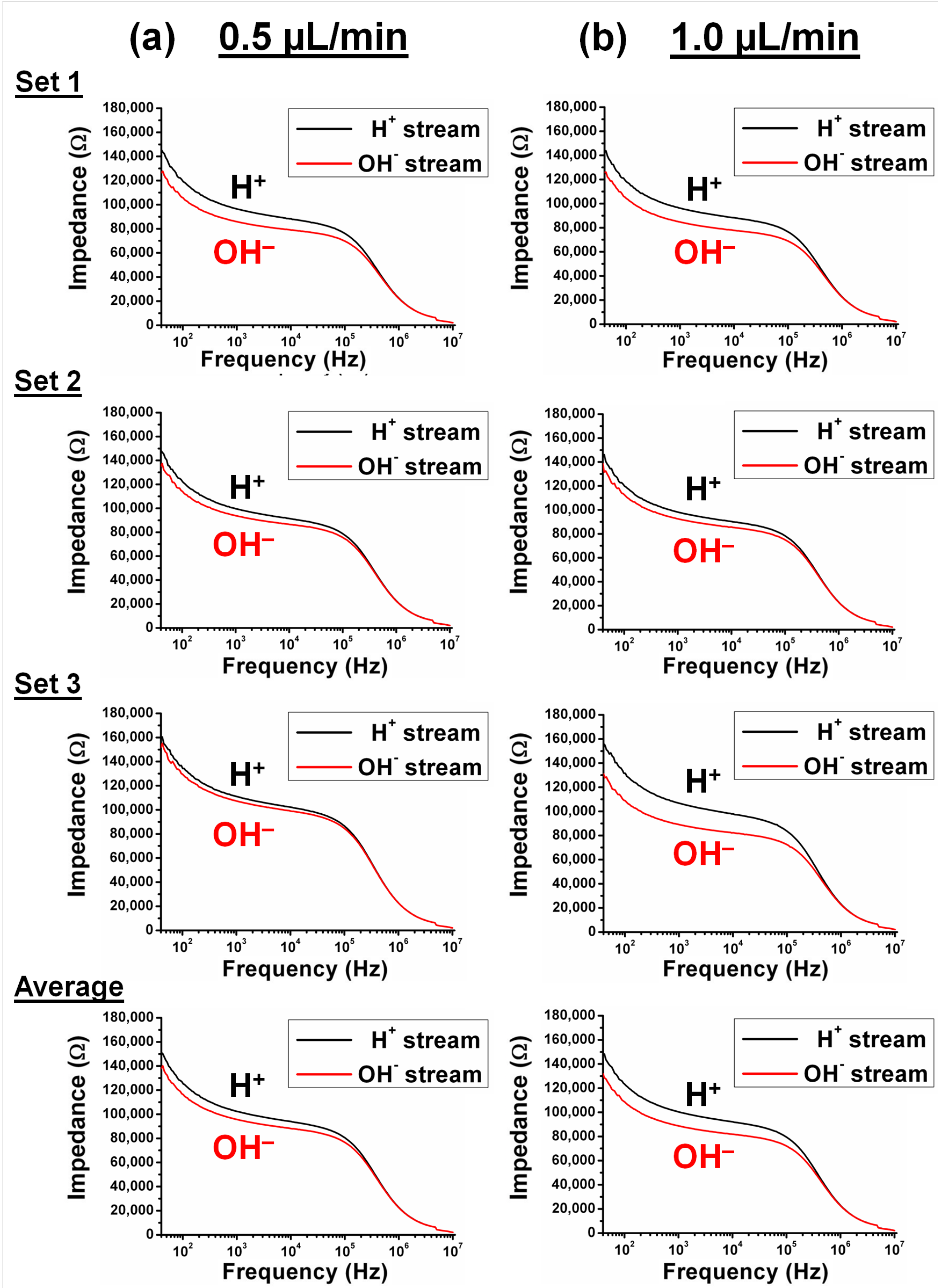

Figure S2. Plots of impedance versus frequency for H^+ and OH^- samples collected at flow rate of (a) 0.5 µL/min, and (b) 1.0 µL/min.

(3) Pair-sample *t*-test on the Impedance Data

Figure S3 shows the impedance values obtained from Figure S2 at 1 kHz from both flow rates which were used for statistical analysis. A paired sample t-test was conducted to verify if the H^+ stream had higher impedance value than the OH^- stream as follows:

Paired-sample *t*-test:

Null hypothesis, H0: $\mu + - \mu - \leq 0$

Alternative hypothesis, H1: $\mu + - \mu - > 0$

For 0.5 µL/min: t-statistic = 3.36024 > $t(\alpha=0.05,\nu=2)$ = 2.919986

For 1.0 µL/min: t-statistic = 3.29217 > $t(\alpha=0.05,\nu=2)$ = 2.919986

Conclusion: Reject H0, accept H1, therefore the impedance of H^+ stream was higher than the impedance of OH^- stream for both flow rates.

The calculated t-statistic concluded that the OH^- stream had impedance lower than the H^+ stream. Therefore, the OH^- stream had conductivity higher than the H^+ stream.

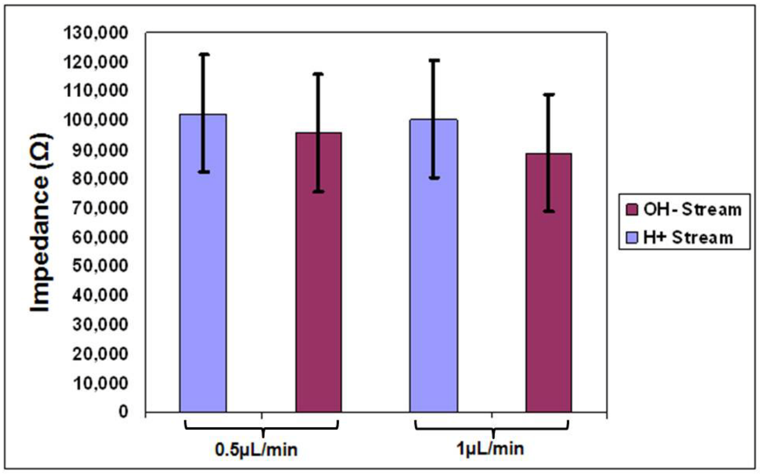

Figure S3. Impedance values of the samples obtained at 1 kHz for 0.5 µL/min and 1.0 µL/min. Impedances values used for conducting pair-sample *t*-test.