

# The Testing of Electro-Osmotic Pumping against Back Pressure

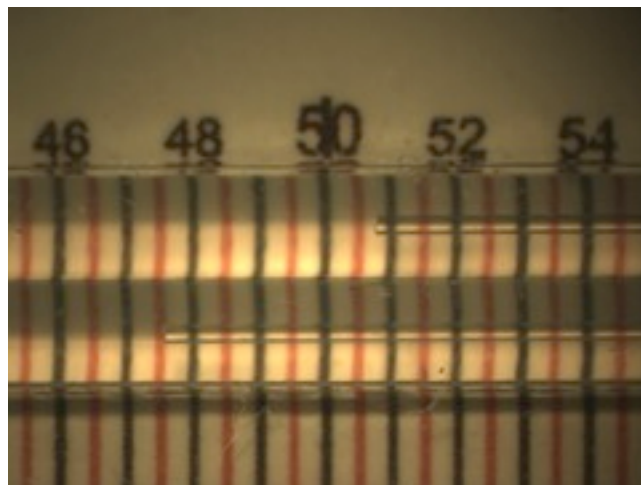
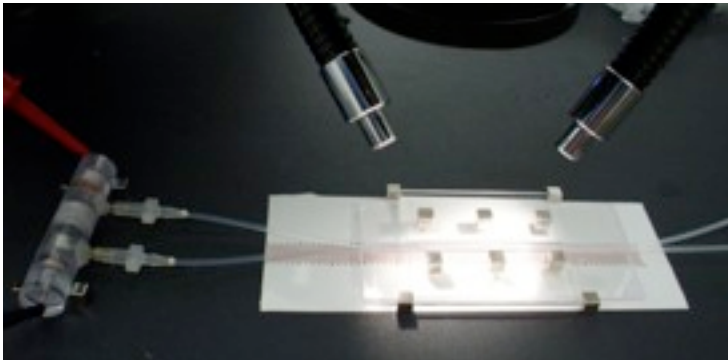
# Objective

To test the capability of nano-pore membrane in generating the electro-osmotic pumping against a range of back pressures under a limiting condition to avoid gas evolution in Ag/AgCl electrolytic cell

# Overview

- The electro-osmotic (EO) pumping is tested against a range of constant back pressures.
- The EO testing device is based on an Ag/AgCl electrolytic system in which 100 mM of NaCl(aq) is used as electrolyte in this experiment.
- Theoretically, the applied voltages need to be below 700 mV to avoid bubble formation at the concentration of 100 mM.
- An adjustable voltage source is used to apply a constant voltage across the cell, while the current is being monitored throughout the experiment.

# Experiment Setup



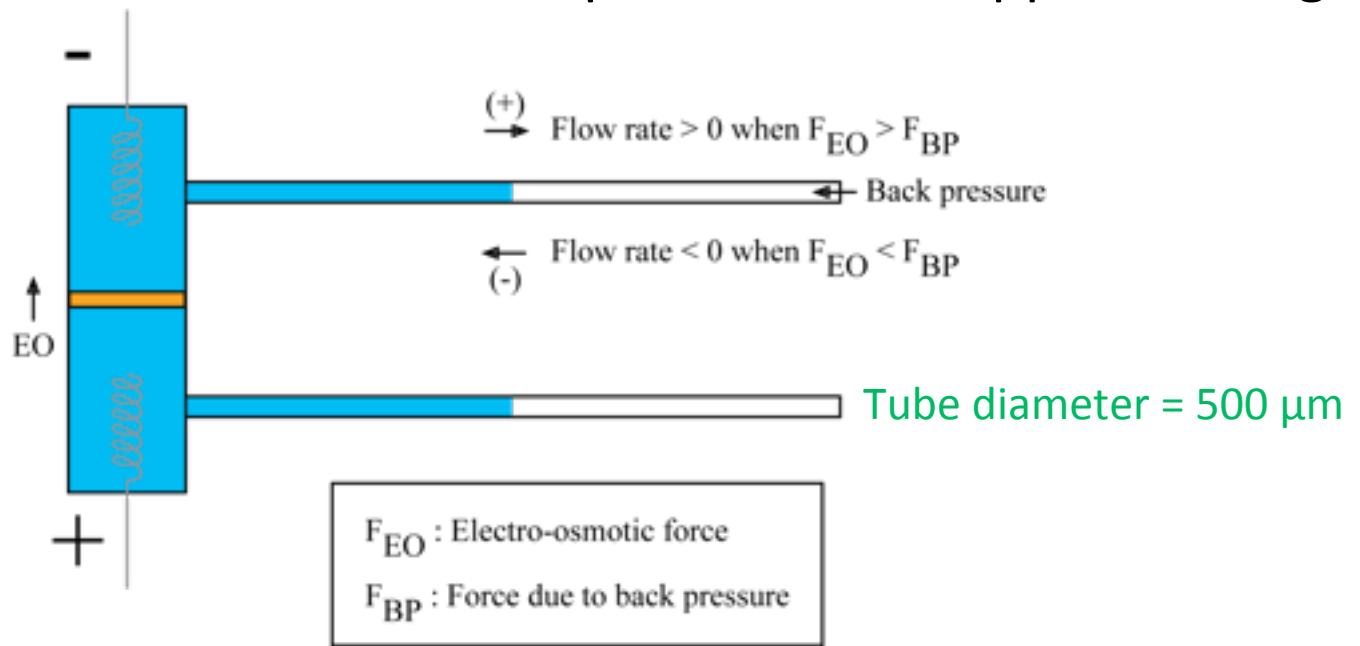
- A precision air pressure regulator is used to supply a constant back pressure.
- Tubing with 250  $\mu\text{m}$  in diameter (49 nL/mm) allows low flow rates to be visually monitored comparing to that with 500  $\mu\text{m}$  (196 nL/mm).
- The flows in both tubes are monitored under a microscope.

# Procedures

- Turn on and adjust the air pressure regulator, and measure the rate of pressure-driven flow
- Turn off the regulator, apply the voltage, and measure the EO flow rate
- Then turn on the regulator to apply the back pressure and measure the flow rate
- Finally, stop applying the voltage, and measure the pressure-driven flow again to compare with the previously measured
- Repeat the steps for each value of the back pressure

Note: The omission of EO flow rate verification at the end of each experiment is due to a significant drop in the current during the test.

Table 1: Flow rates at various back pressures and applied voltages



Flow rate (nL/min)		Pressure (psi)						
		0	0.05	0.1	0.15	0.2	0.25	0.3
Voltage (mV)	0	0	-21.55 ± 7.22	-186.24 ± 29.14	-315.56 ± 90.92	-399.26 ± 93.88	-471.61 ± 116.41	-539.51 ± 234.56
	500	391.98 ± 120.06	174.09 ± 24.30	55.07 ± 7.26	0 ± 0	-3.59 ± 3.39	-40.11 ± 10.22	-111.94 ± 14.47
	600	499.76 ± 105.82	263.20 ± 37.72	122.67 ± 25.31	30.10 ± 3.62	-0.60 ± 1.69	-23.95 ± 7.68	-71.28 ± 17.47

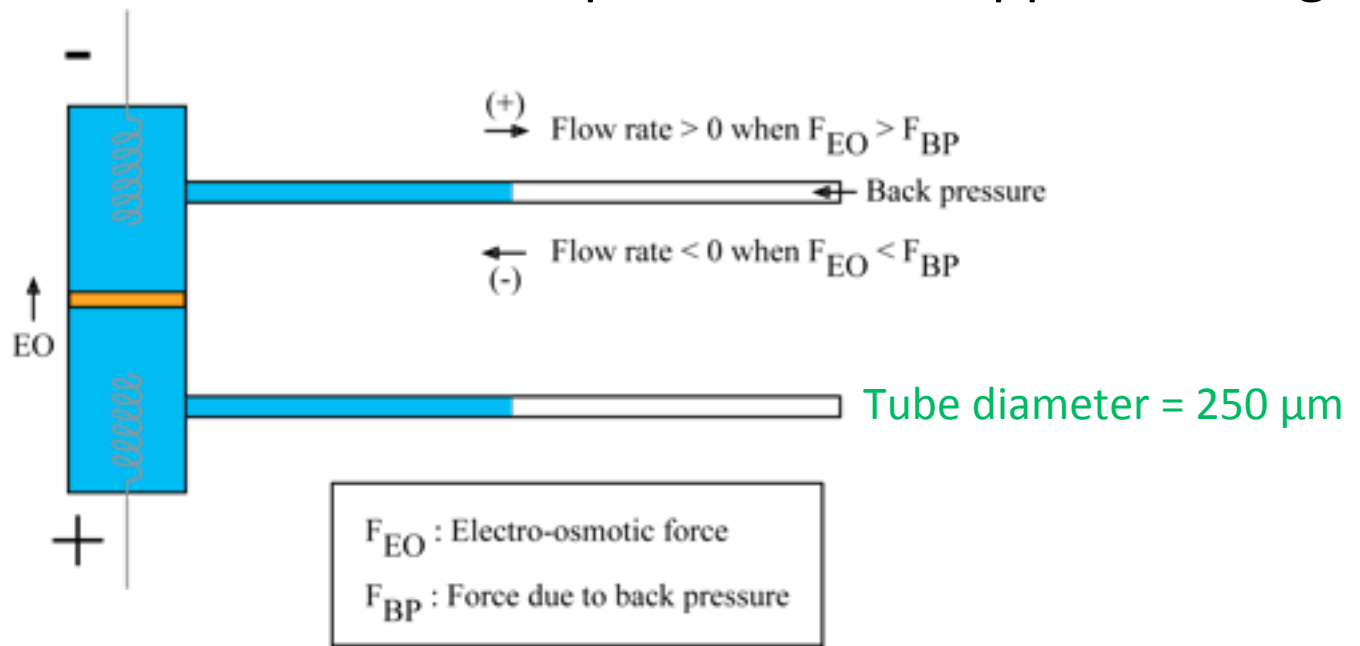
# Figure 1: Flow rate vs back pressure

Figure 1 shows the rates of the electro-osmotic flow against various back pressures for different applied voltages.

# Figure 2: Monitoring the currents

Figure 2 shows the statistic of the current during each experiment where their average values are plotted and their standard deviations are depicted by error bars.

Table 2: Flow rates at various back pressures and applied voltages



Flow rate (nL/min)		Pressure (psi)						
		0	0.05	0.1	0.15	0.2	0.25	0.3
Voltage (mV)	0	0	$-1.27 \pm 0.45$	$-1.64 \pm 0.61$	$-56.80 \pm 12.57$	$-279.59 \pm 53.59$	$-487.67 \pm 50.60$	$-664.67 \pm 36.64$
	500	$130.73 \pm 57.00$	$4.03 \pm 1.23$	$0.75 \pm 0.26$	$-0.03 \pm 0.41$	$-1.03 \pm 0.51$	$-1.73 \pm 0.51$	$-2.82 \pm 0.79$
	600	$234.82 \pm 43.38$	$54.23 \pm 13.29$	$20.24 \pm 17.55$	$8.73 \pm 2.26$	$1.98 \pm 2.20$	$0.01 \pm 0.55$	$-1.60 \pm 1.16$

# Figure 3: Flow rate vs back pressure

Figure 3 shows the rates of the electro-osmotic flow against various back pressures for different applied voltages.

# Figure 4: Monitoring the currents

Figure 4 shows the statistic of the current during each experiment where their average values are plotted and their standard deviations are depicted by error bars.

# Discussions

- Positive flow rates are achieved against the maximum back pressure of 0.15 psi for both tubes at 600 mV of the applied voltage.
- Tube with a smaller diameter allows low flow rate to be visually monitored, but imposing higher fluidic friction that significantly reduces the flow rate particularly at the pressures below 0.25 psi.
- It is found that by applying the voltage across the membrane, the fluid flow through the membrane is significantly resisted as compared to the corresponding flow rate when no voltage is applied.