Electronic Supplementary Material (ESI) for Analytical Methods.

Ionic electroactive polymer actuators as active microfluidic mixers

Supporting Material

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Video file of mixing experiment:

All image analysis for the associated paper was conducted from individual frames selected from this file; it is unmodified from its original form except that it has been shortened to the relevant frames. The video begins at T0, which corresponds to when the actuator was activated, and terminates at T20. Flow is from left to right down the microchannel.

Reynolds and Péclet Number Calculations:

The Reynolds and Péclet numbers were determined as follows:

$$Re = \frac{QD_H}{\nu A}$$

$$where\ D_H = \frac{4A}{P}\ and\ \nu = \frac{\mu}{\rho}$$

$$Pe = \frac{QD_H}{AD}$$

Where D_H = hydraulic diameter, Q = volumetric flow rate, ν = kinematic viscosity, μ = fluid viscosity, ρ = fluid density, A = channel cross-sectional area, and P = wetted perimeter, and D = diffusivity.

Note: Values of μ and ρ are assumed to be that of water at 20°C. For the Péclet number calculation, the diffusivity for water with dye was determined in previous work to be $D = 1 * 10^{-10}\, m^2/s$, as cited below.

Hashemi, Nastaran, et al. "Dynamic reversibility of hydrodynamic focusing for recycling sheath fluid." *Lab on a Chip* 10.15 (2010): 1952-1959.

Effect of Polyethylene Cover on Displacement:

The polyethylene cover significantly reduces the displacement of the actuator tip, largely due to its weight contribution along the actuator length. Tests were conducted to quantify the extent to which the cover inhibits tip displacement compared to a free actuator (without cover), as shown in Figure S2. The actuators were operated in the same manner as described in the associated paper and their motion was recorded using a charge coupled device (CCD) camera at 30fps. Individual frames were analyzed to determine tip displacement at various frequencies. Figure 2 plots the total tip displacement, which measures the sum of the displacement from each side of center (resting position) for consecutive frames. Tests were conducted at multiple frequencies. As frequency increases, the displacement decreases, as expected, because the actuator has less time to respond. However, the cover inhibits the motion of the actuator significantly, although the total displacement is still large relative to the height of the microchannel (400 μm).

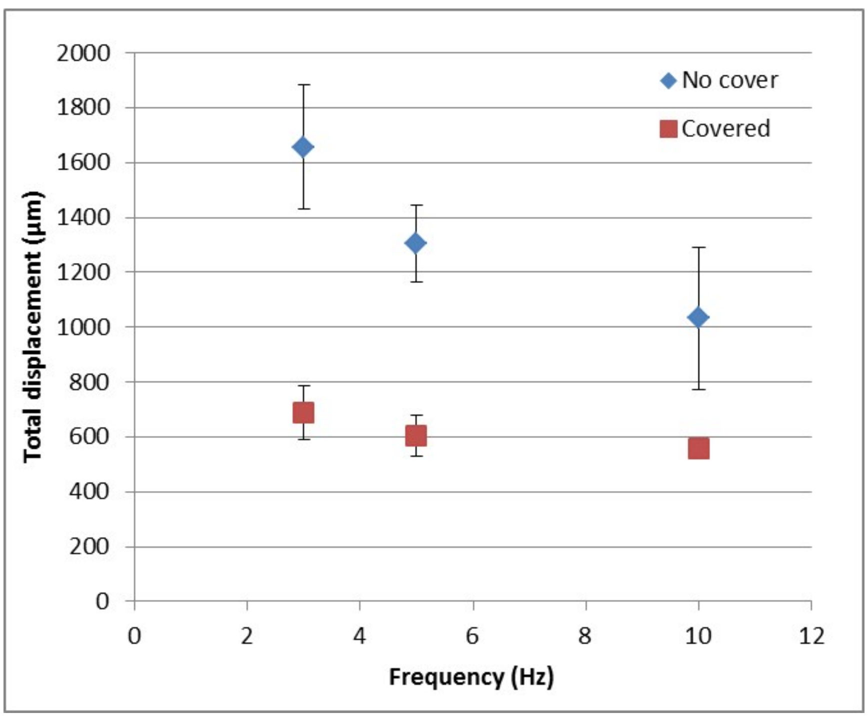

Figure S2: Total tip displacement of IEAP actuators.

Effect of Compression in Microchannel on Displacement:

Tests were conducted in the same manner as described for Figure S2, except an actuator was compressed between 2 layers of PDMS, as it would be inside the microchannel. Similarly, Figure S3 plots the total tip displacement at multiple frequencies. Compressing a portion of the length of the actuator also inhibits tip displacement, although the remaining displacement compared to the height of the channel (400 µm) should be significant enough to disrupt fluid flow within the confines of the microchannel.

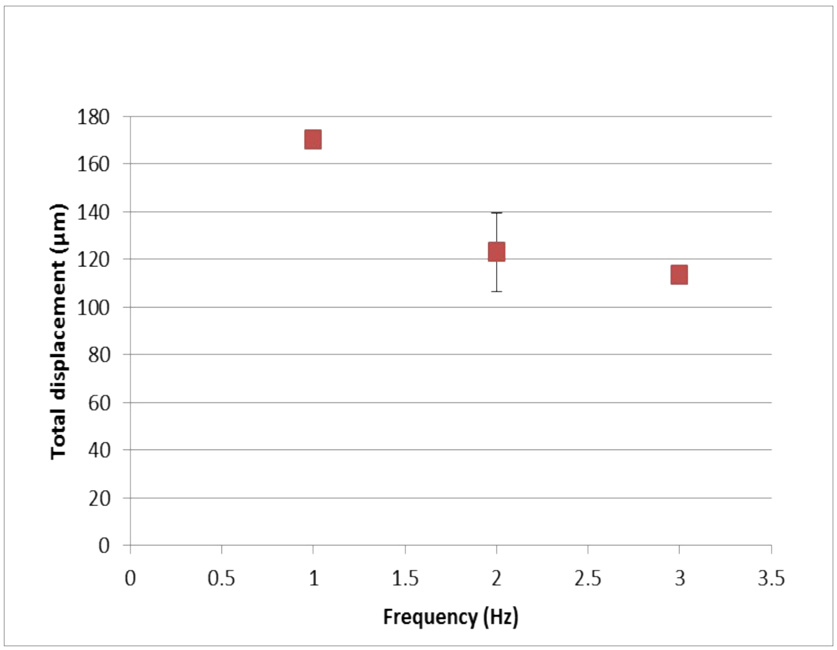

Figure S3: Total tip displacement of IEAP actuators in polyethylene cover in simulated microchannel.