A RAPID FIELD-FREE ELECTROOSMOTIC MICROPUMP INCORPORATING CHARGED MICROCHANNEL SURFACES

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Abstract

A rapid field-free electroosmotic micropump (RFEP) was constructed incorporating separate anionic and cationic glass microchannel surface modifications and its performance was investigated. Two of the arms of the devised Y-shaped RFEP were coated with anionic and cationic polymers, respectively. Different charges localized on these interior surfaces produced electroosmotic flow in opposite directions when an electric field was applied along the two coated arms. The hydrodynamic pressure developed at the common junction of the three arms generated field-free flow, which responded rapidly and reversibly to the applied electric field. The flow rate of the devised RFEP was 98.4 nL min^{-1} when 1.0 kV was applied in 10 mM phosphate buffer at pH 7.0.

Keywords: Micropump, Electroosmotic flow, Microfluidics

1. Introduction

Micropump is a key component in microfluidic system. Many micropumps with various operating principles were developed [1]. For those micropumps, micropump using electroosmotic flow (EOF) is suitable for miniaturizing system size and generating rapid-responding flow. However, EOF is sensitive to microchannel surface adsorption and high electric field of EOF causes problems, such as cell lysis [2]. Producing electroosmotically driven field-free flow on a microchip is a solution to the developing micropump for microfluidic system.

The key concept used in the present study was a 'T'-shaped channel network design with two arms with positively and negatively charged interior surfaces, respectively. The schematic in Figure 1 shows how the T-shaped channel works. Although an electric potential is applied across the charged horizontal arms, no field gradient exists in the vertical channel, which is thus field free. Moreover, the fluid in the field free vertical channel can be made to move upwards (Figure 1(B)) or downwards (Figure 1(C)) by switching the polarity of the field applied potential across the two horizontal arms; it also respond reversibly to an applied voltage like a plain EOF.

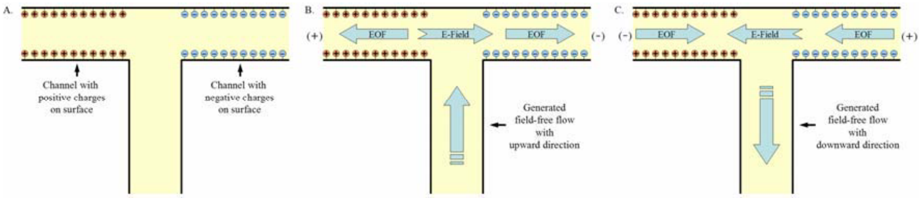

Figure 1. Schematic of field-free flow generation by modifying the surface of microfluidic chip.

2. Experimental Results

Figure 2 shows the schematic design of the proposed RFEP. The two upper arms with different interior surface charges and the vertical field-free channel were connected at the buffering region. Channel width and height is 30 μm and the diameter of buffering region is 300 μm. Glass chip was fabricated using general photolithography, etching and thermal bonding processes.

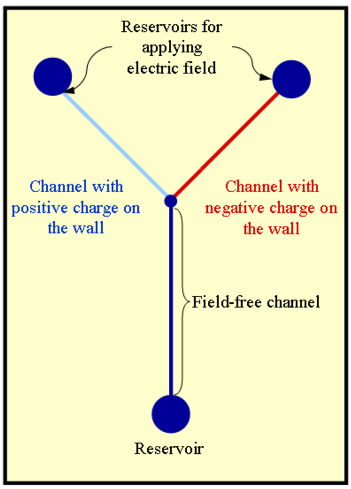

Figure 2. Schematic design of the proposed RFEP.

The output flow rates of the developed RFEP were measured by changing the applied voltages between the charged channel reservoirs. The channel was filled with 10 mM phosphate buffer (PB) at pH 7.0 and the resistance of the upper two arms was 148 MΩ. The slope of the flow rate versus applied voltage was 98.4 nL min^{-1} kV^{-1}. Detailed results are shown in Figure 3, which shows that the flow rate increased linearly from 50 to 200 nL min^{-1} as the applied potential was increased from 0.5 to 2.0 kV These flow rates are rather slower compared with those previously reported for EOF micropumps. With the achieved pumping rate, we could transfer object with speed of 1.85 mm s^{-1} when applied 1 kV assuming 30 μm × 30 μm channel dimension.

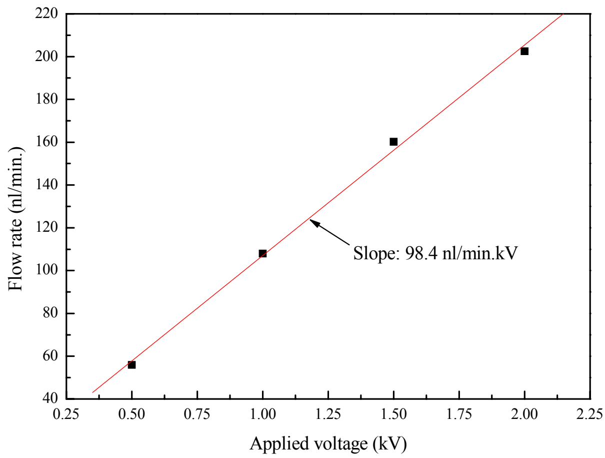

Figure 3. Flow rate versus applied electric filed.

3. Conclusion

We have described a novel rapid field-free electroosmotic micropump (RFEP) which is driven by selectively coated microchannels. The devised RFEP was fabricated using general microfabrication techniques, thus ensuring its straightforward fabrication and combination with other microfluidic elements. The flow rate of the devised RFEP was found to be directly proportional to the applied electric field with a slope of 98.4 nL min^{-1} kV cm^{-1} in 10 mM PB at pH 7.0

References

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