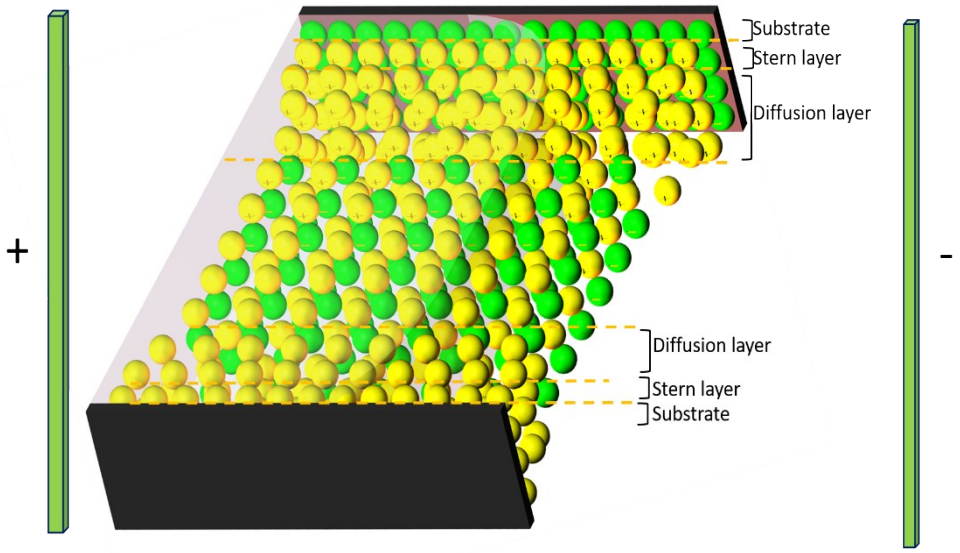
Electronic Supplementary Material (ESI) for Lab on a Chip.

Fused Filament Fabrication 3D Printed Polylactic Acid Electroosmotic Pumps

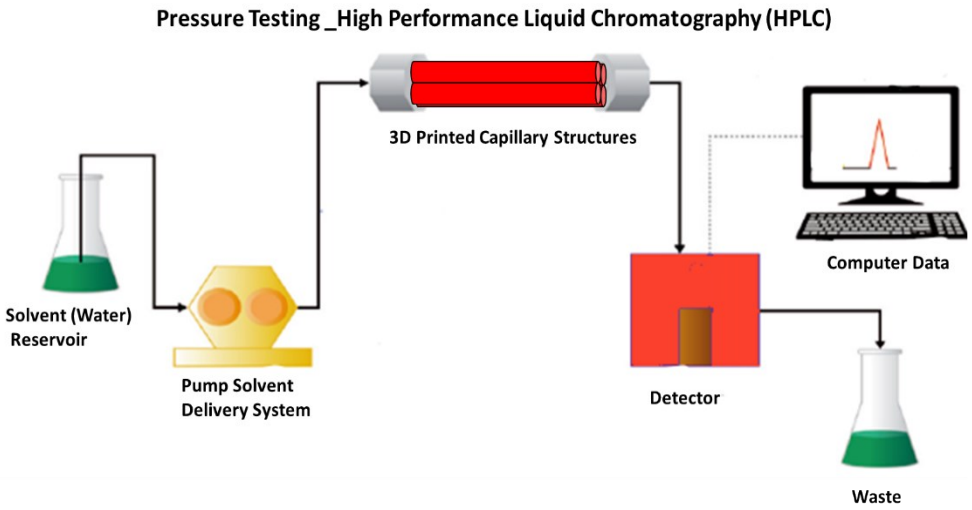
Liang Wu,[a,b*] Stephen Beirne,[a,c] Joan Marc Cabot,[b] Brett Paull,[b] Gordon G. Wallace,[a,c] and Peter C. Innis[a,c*]

[a.] *ARC Centre of Excellence for Electromaterials Science (ACES), Intelligent Polymer Research Institute, University of Wollongong, Australia 2522*
[b.] *ARC Centre of Excellence for Electromaterials Science (ACES), Australian Centre for Research on Separation Science (ACROSS), School of Natural Sciences | College of Sciences and Engineering, University of Tasmania, Australia 7005*
[c.] *Australian National Fabrication Facility - Materials Node, University of Wollongong, Australia 2522*

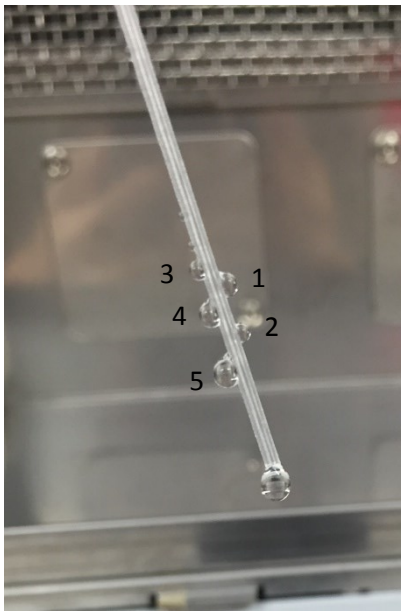
Electronic Supplementary Information



Supplementary Figure S1 A schematic illustration of electric double layer (EDL) and electroosmotic flow (EOF). The double layers refer to two parallel layers of charge surrounding a channel with a negatively charged surface. The first layer consists of ions adsorbed onto the surface of the channel due to chemical interactions, or "Stern layer". The second "diffusion layer" is composed of ions attracted to the surface charge by the columbic force, electrically screening the first layer. When solvated ions within the diffusion layer move under the influence of the electric field, these ions drag the surrounding solvent along with them due to the viscous ion effect, resulting in bulk fluid motion known as EOF. Yellow and green spheres represent cations and anions, respectively. A translucence part on the left side of channel represents the EOF.



Supplementary Figure S2 A schematic diagram of pressure testing for 3D printed capillary structures using high performance liquid chromatography (HPLC) system. During the tests, HPLC column was replace by the 3D printed capillary structures and the data of back-pressure were collected via computer system.



Supplementary Figure S3. Leaks detection using visual inspection. At least 5 leaks (labelled) were observed along the tested sample. Note: this picture only represents the observation of leaks during the experiments to clarify the pressure testing method, but it does not demonstrate the leakage of PLA single-capillary samples reported in Figure 4.

Figure S4A

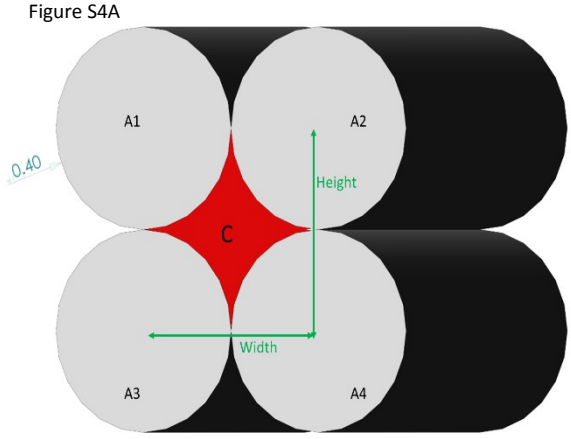
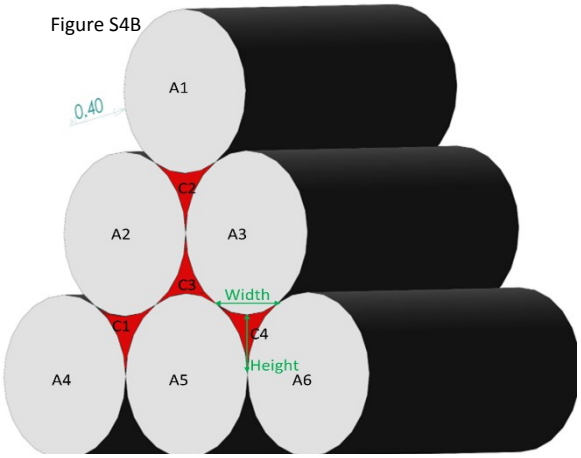


Figure S4B

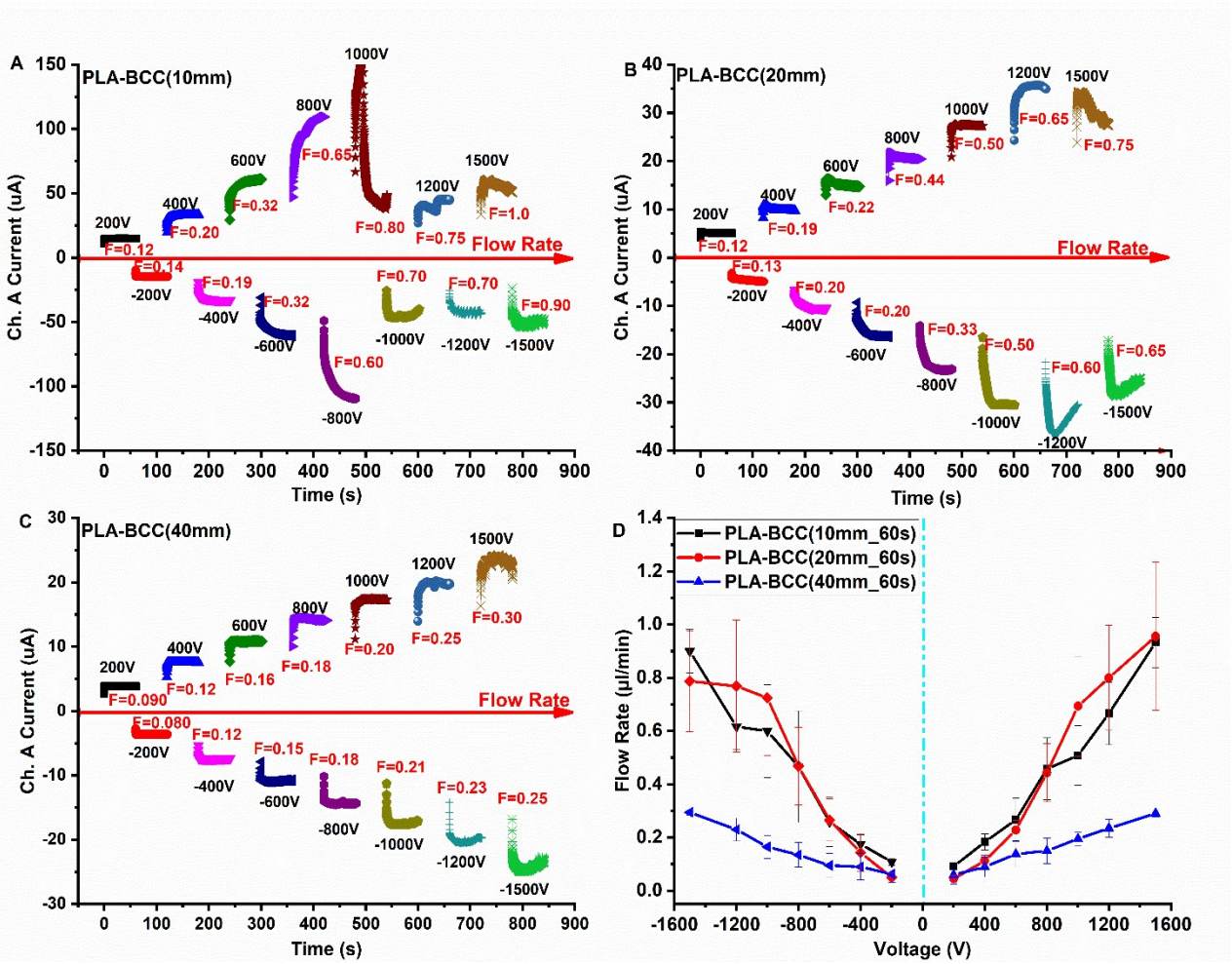


Supplementary Figure S4 (A) FCC 1-capillary designed structure. (B) FCC 1-capillary designed structure

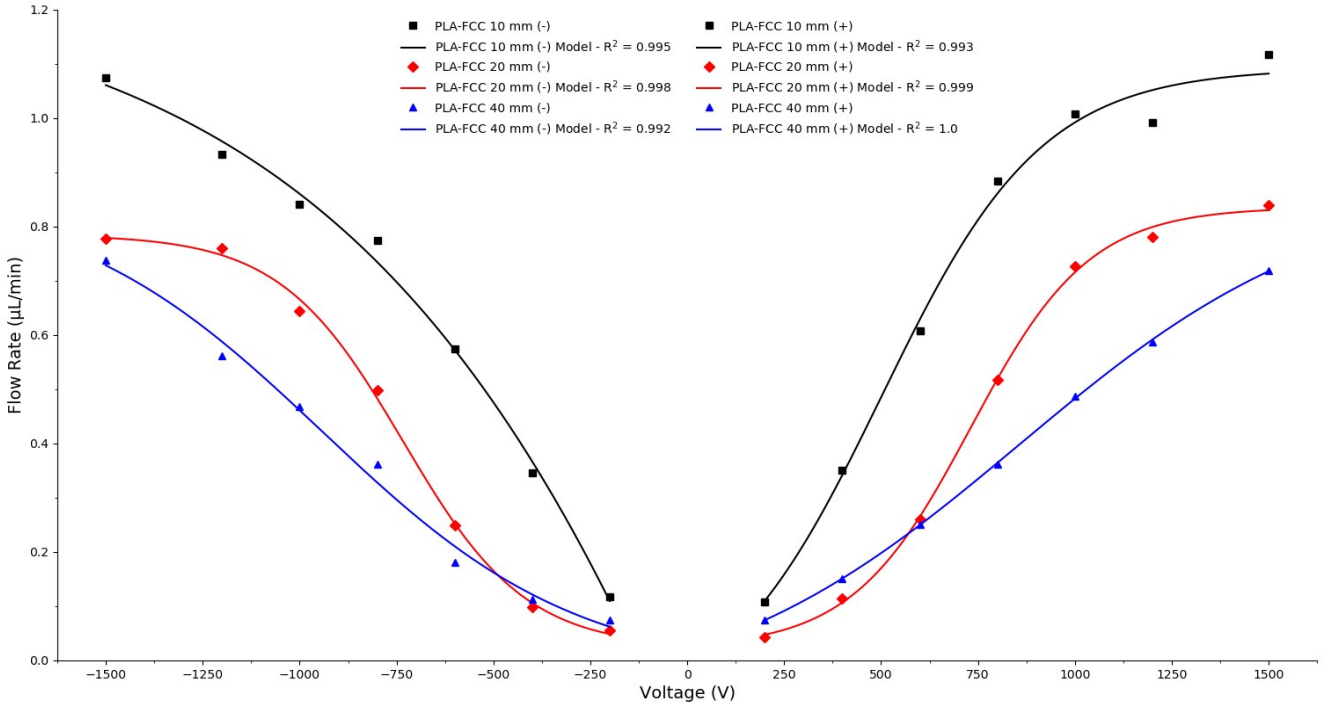
In Figure S4A, A1, A2, A3 and A4 (log-like shapes) represent the extruded PLA filaments. C (highlighted in red) represents the capillary (microchannel) based on the FCC configuration. The FCC capillary structure is composed of 4 extruded PLA filaments (A1~A4) and 1 capillary (C). During the dimensional measurement of FCC capillary structures, FCC overall area (Table 2) means the area of the FCC capillary structure, while capillary overall area means the area of all capillaries. $A_{capillaries}/A_{structure}$ ratio means that the ratio of the area of capillary (capillaries) to the area of FCC capillary structure. Capillary average area means the average area of the formed FCC capillaries. The dimensions of capillaries (width and height) were labelled using green arrows.

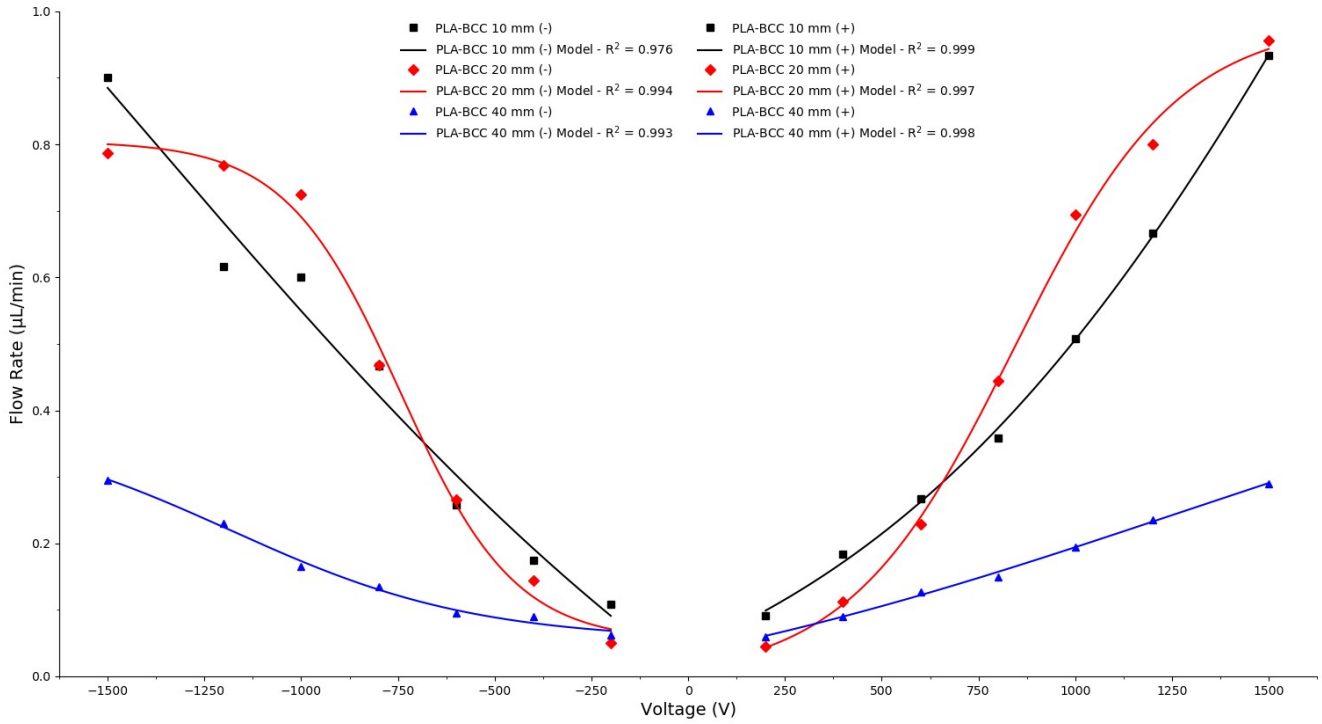
In Figure S4B, A1~A6 represent the extruded PLA filaments. C1~C4 represent the capillaries (microchannels) based on the BCC configuration. The BCC capillary structure is composed of 6 extruded PLA filaments (A1~A6) and 4 capillaries (C1~C4). During the dimensional measurement of BCC capillary structures, BCC overall area (Table 2) means the area of BCC capillary structure, while capillary overall area means the area of all capillaries. $A_{holes}/A_{structure}$ ratio means that the ratio of the area of capillary (capillaries) to the area of BCC capillary structure. Capillary average area means the average area of the formed BCC capillaries.

In Table 2, the number of the tested single-capillary samples was 5 while the figure of the tested multi-capillary samples was 3. The error bars are one standard deviation. Image J was used to measure the dimensions and areas of the printed capillary samples including the capillaries formed by the filaments and the extruded filaments.

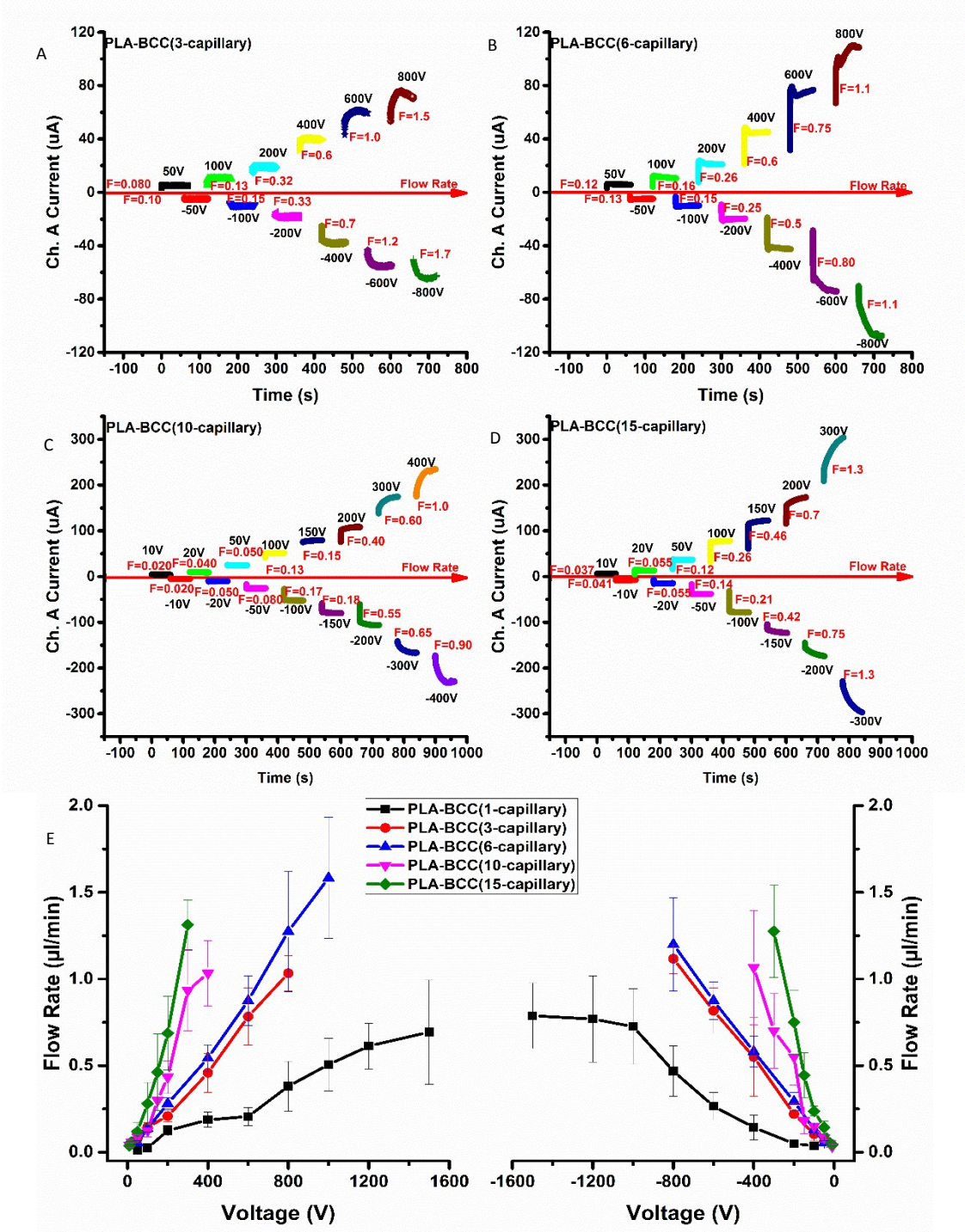


Supplementary Figure S5 The flow properties of BCC single capillary EOP (A) The current versus test time of BCC EOP (10mm). (B)The current versus test time of BCC EOP (20mm). (C) The current versus test time of BCC EOP (40mm). (D) The flow rate of BCC EOP with various lengths versus applied voltage.

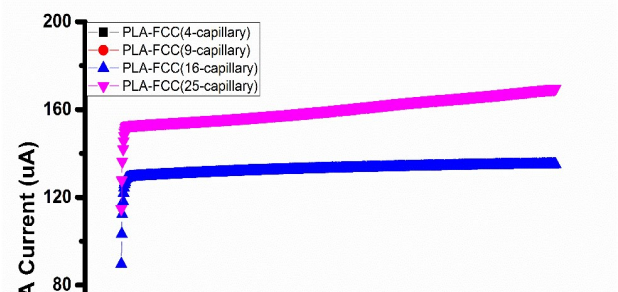


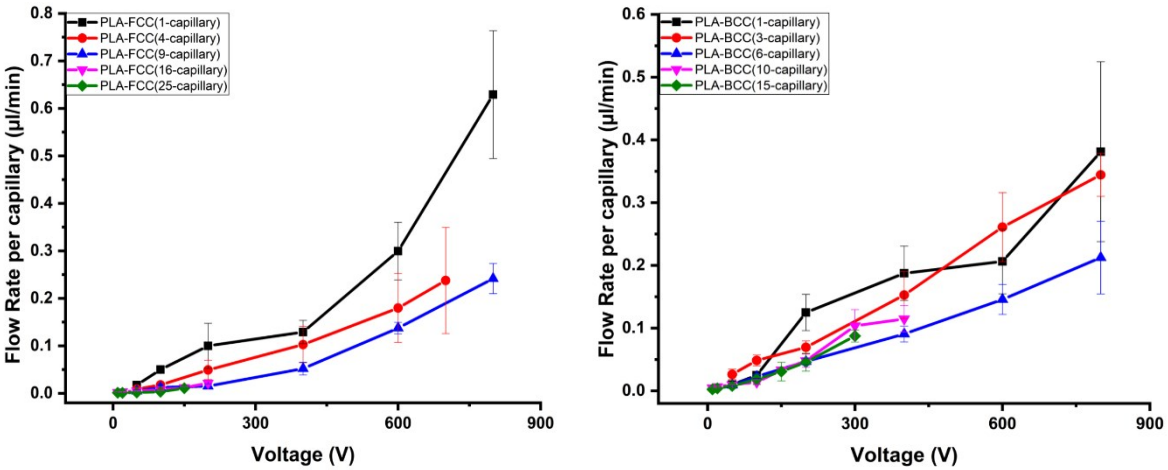


Supplementary Figure S6 (A) The flow rate of FCC EOP with various lengths versus the applied voltage. (B) The flow rate of BCC EOP with various lengths versus the applied voltage. The points represent the average of successive measurements, the error bars are the standard deviation, and the lines represent sigmoid models (R2>=0.976, n=7).



Supplementary Figure S7 The properties of BCC multi-capillary EOP (20mm). (A) The current versus the test time of BCC 4-capillary EOP; (B) The current versus the test time of BCC 9-capillary EOP; (C) The current versus the test time of BCC 16-capillary EOP; (D) The current versus the test time of BCC 25-capillary EOP; (E) The flow rates of BCC EOP with the different number of capillaries versus applied voltage





Supplementary Figure S9 The flow rate of FCC and BCC EOP per capillary versus applied voltage.