

## Supplementary Information

### **Nematic liquid crystal flow in microchannels with patterned anchoring**

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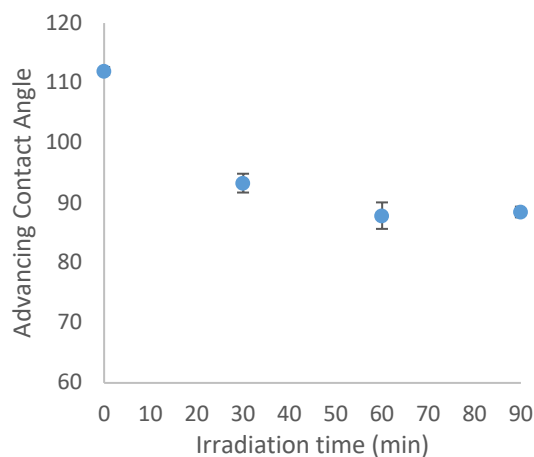
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## Supplementary Note 1: Wettability Measurements

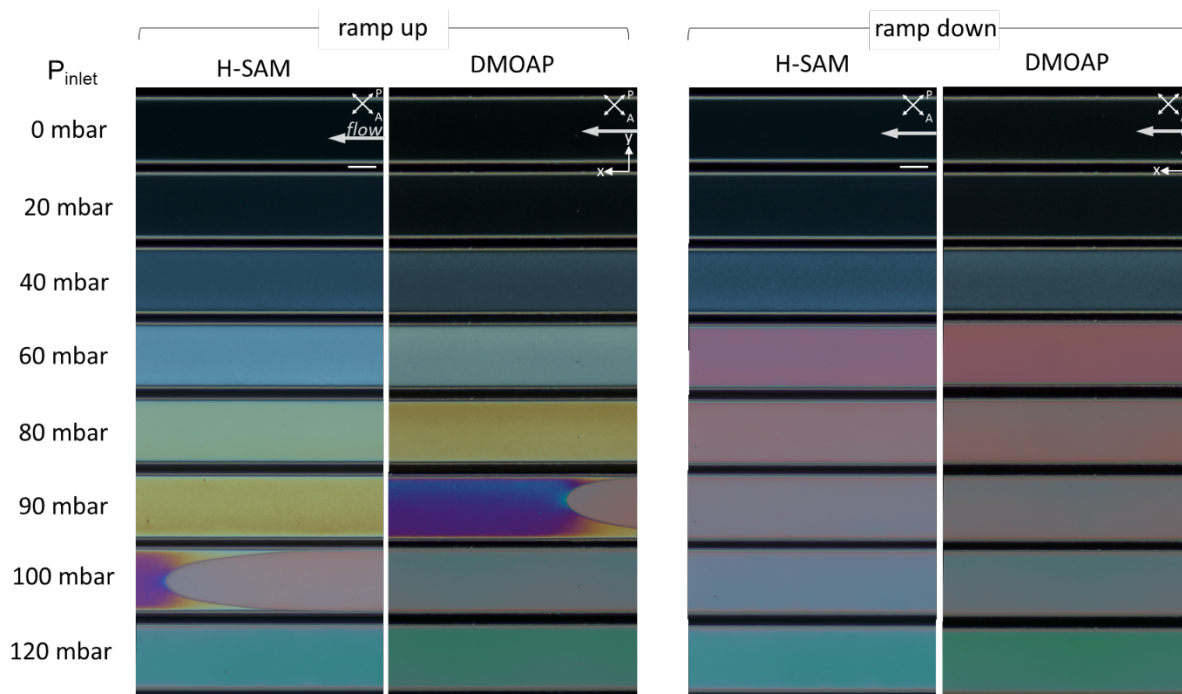
### Measurements of Advancing Contact Angle

The advancing contact angle of water on H-SAM-modified glass surfaces was measured with the changing irradiation time of H-SAM for the photocleaving of H-SAM-modified surfaces. As can be seen in Supplementary Figure 1, the advancing contact angle of water of  $112.0^\circ \pm 0.6^\circ$  on a flat surface as modified with H-SAM. When H-SAM was exposed to 30 minutes of UV irradiation, the contact angle of water was decreased to  $93.3^\circ \pm 1.6$ , signifying cleaving of o-nitro-benzyl groups, and the exposure of carboxylic acid groups was increased. While the irradiation time was increased, a slight change was observed between the data of 1 hr and 90 minutes, as can be seen in Supplementary Figure 1. 1 hr UV irradiation reduced the contact angle to  $87.9^\circ \pm 2.2^\circ$ , and 90 minutes irradiation resulted in  $88.5^\circ \pm 0.9^\circ$  of advancing contact angle.



**Supplementary Figure 1.** The advancing contact angle of water on H-SAM-modified glass with changing irradiation time

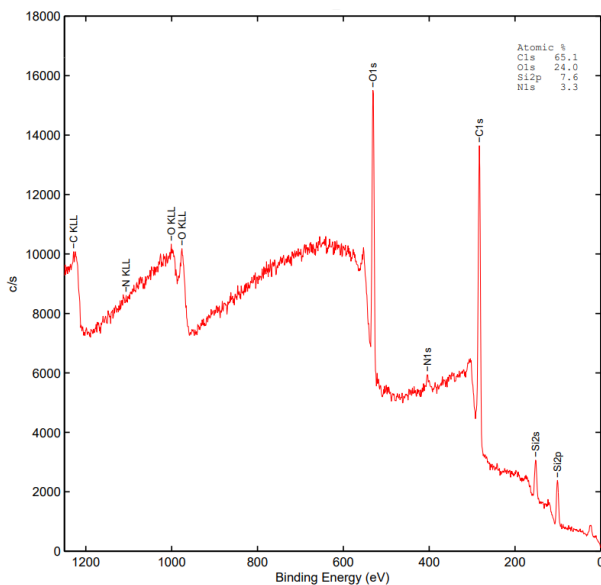
**Supplementary Note 2: Investigation of pressure-driven nematic 5CB flow under polarized optical microscopy during ramp-up and ramp-down inlet-pressure conditions in H-SAM- and DMOAP-modified homeotropic microchannels**



**Supplementary Figure 2.** Polarized optical microscopy images of flowing nematic 5CB in the H-SAM and DMOAP modified channel (homeotropic interfaces) at the indicated inlet pressures in increasing (ramp up) and decreasing (ramp down) inlet pressure directions. The analyzer and polarizer are crossed at  $45^\circ$  and  $135^\circ$ . Scale bars: 100  $\mu\text{m}$ .

### Supplementary Note 3: XPS Characterizations of the H-SAM Interfaces

0.23% (v/v) of H-SAM solution in hexadecane was prepared, and plasma-applied glass slides were immersed in the solution for coating. After 30 minutes, they were rinsed with isopropanol and dried with nitrogen gas. For photocleaving, the glasses were exposed to 1 hr UV exposure while they were immersed in isopropanol.

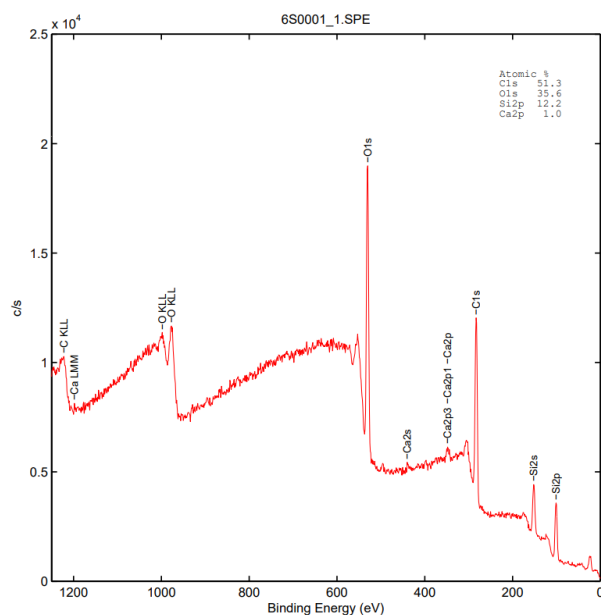


**Supplementary Figure 3.** XPS result of the H-SAM modified glass surface

**Supplementary Table 1.** The atomic percentages of XPS results of the H-SAM-modified glass surface

| Atomic% |      |
|---------|------|
| C1s     | 65.1 |
| O1s     | 24.0 |
| Si2p    | 7.6  |
| N1s     | 3.3  |

# Supplementary Note 4: XPS Characterizations of the photocleaved H-SAM (pH-SAM) Interfaces

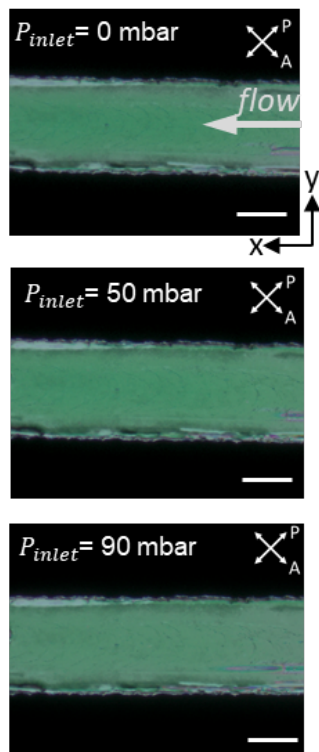


**Supplementary Figure 4.** XPS result of the 1 hr UV exposed- H-SAM modified glass surface

**Supplementary Table 2.** The atomic percentages of XPS results of 1-hr UV-exposed- H-SAM modified glass surface

| Atomic% |      |
|---------|------|
| C1s     | 51.3 |
| O1s     | 35.6 |
| Si2p    | 12.2 |
| Ca2p    | 1.0  |

**Supplementary Note 5: Investigation of pressure-driven nematic 5CB flow under polarized optical microscope in PEG silane modified planar channels**



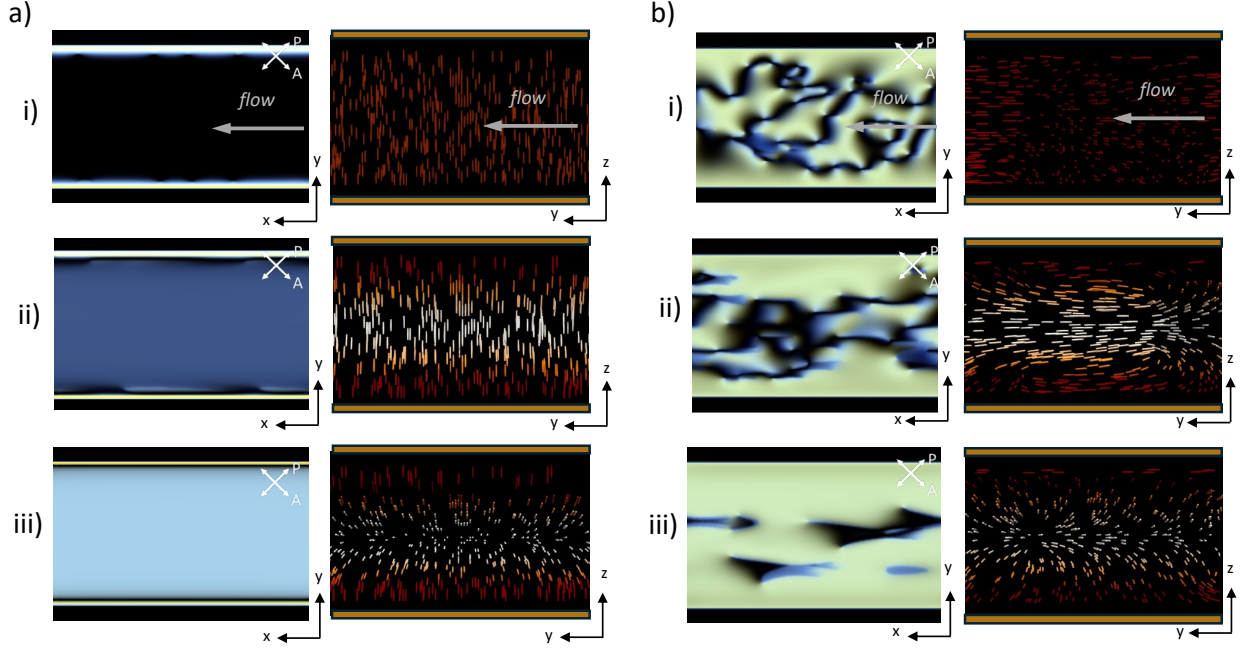
**Supplementary Figure 5.** Micrographs of flowing nematic 5CB in the PEG silane modified (planar) channels at the indicated inlet pressures in increasing (ramp up) direction. The analyzer and polarizer are crossed at  $45^\circ$  and  $135^\circ$ . Scale bars:  $100 \mu\text{m}$

**Supplementary Note 6: The pressure and body force values of the data provided in Fig. 1 and Fig. 5**

**Supplementary Table 3.** The experimental pressure and simulated body force values of the data provided in Fig 1 and Fig. 5

|               |         |     | <b>Experiments<br/>(mbar)</b> | <b>Simulations<br/>(body force)</b> |
|---------------|---------|-----|-------------------------------|-------------------------------------|
| <b>Fig. 1</b> | Panel d | i   | 10                            | 1.00E-10                            |
|               |         | ii  | 50                            | 5.00E-06                            |
|               |         | iii | 100                           | 9.20E-06                            |
|               | Panel e | i   | 5                             | 1.00E-10                            |
|               |         | ii  | 50                            | 2.70E-06                            |
|               |         | iii | 140                           | 5.10E-06                            |
| <b>Fig. 5</b> | Panel a | i   | 0                             | 1.00E-10                            |
|               |         | ii  | 20                            | 7.00E-06                            |
|               |         | iii | 45                            | 9.00E-06                            |
|               | Panel b | i   | 0                             | 1.00E-10                            |
|               |         | ii  | 35                            | 6.00E-06                            |
|               |         | iii | 45                            | 4.00E-06                            |
|               |         | iv  | 50                            | 4.50E-06                            |
|               | Panel c | i   | 0                             | 1.00E-10                            |
|               |         | ii  | 25                            | 4.00E-06                            |
|               |         | iii | 55                            | 2.50E-05                            |

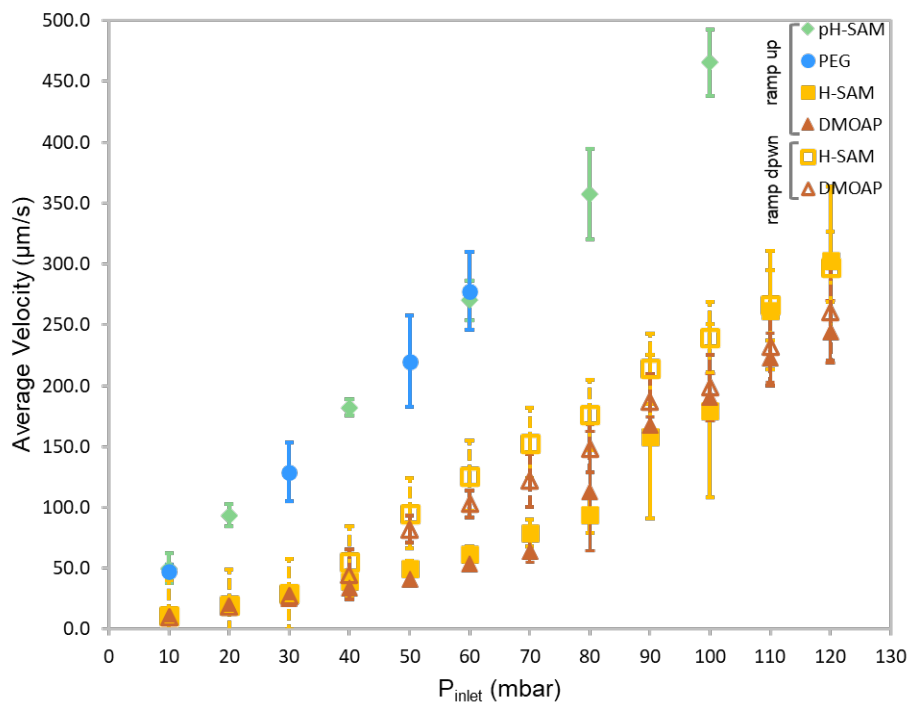
**Supplementary Note 7: Simulated cross-sectional director configurations in microfluidic channels with uniform anchoring**



**Supplementary Figure 6.** Comparison of the liquid crystal director configurations and corresponding cross-polarized microscopy images for unpatterned microchannels and the cross-sectional director configurations for the same simulated states in Fig. 1(d) and Fig. 1(e) corresponding to homeotropic anchoring (panel a) and planar anchoring (panel b), respectively. Sub-panels (i-iii) correspond to weak, medium, and strong flowing states, as shown in Fig. 1.

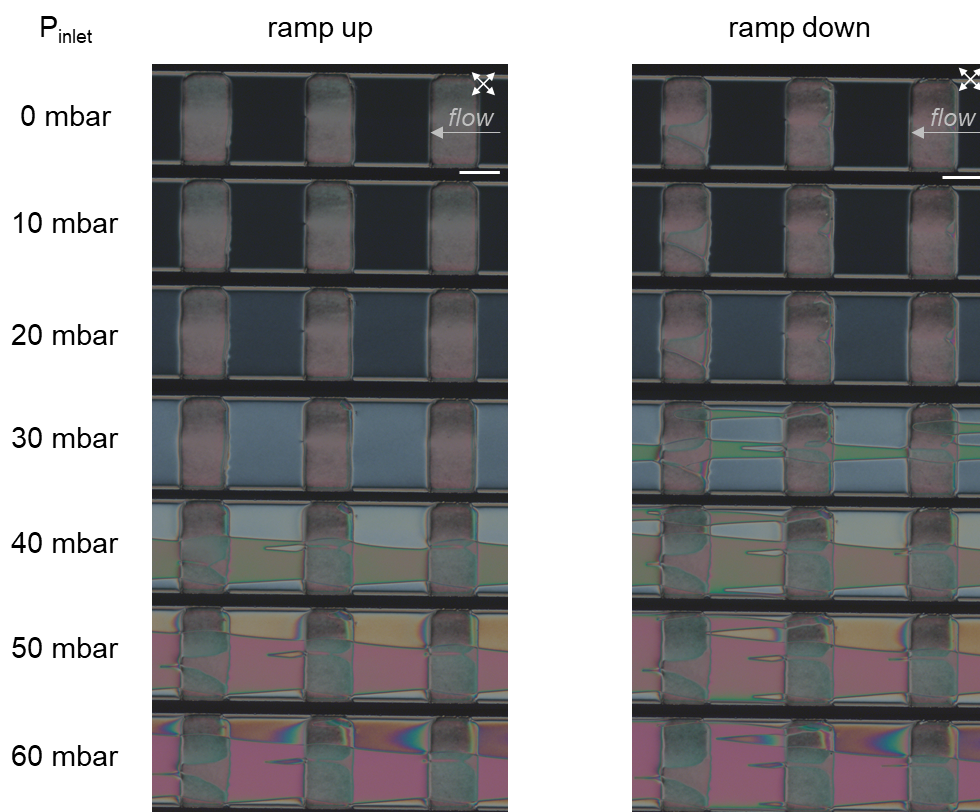
### Supplementary Note 8: The average velocity measurements on the homeotropic and planar channels

The resistances shown in Fig. 2a were calculated using the averaged velocities obtained from particle-tracking measurements. For each inlet-pressure condition, at least three particles were analyzed.

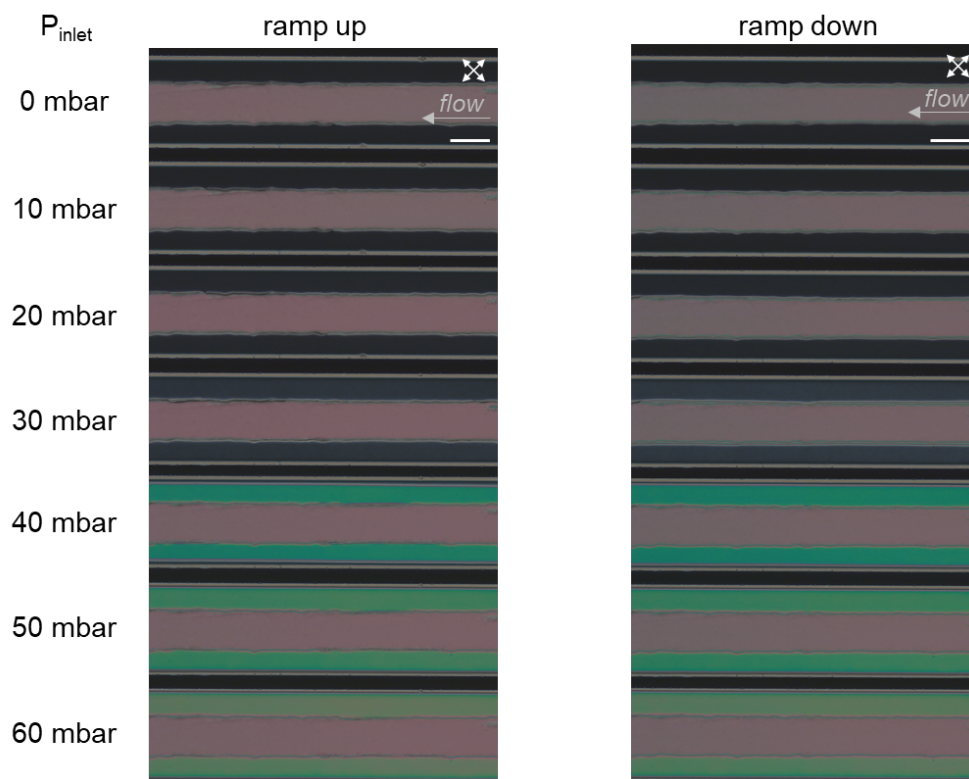


**Supplementary Figure 7.** Average velocity vs.  $P_{inlet}$  graph for nematic 5CB flow in homeotropic and planar microchannels

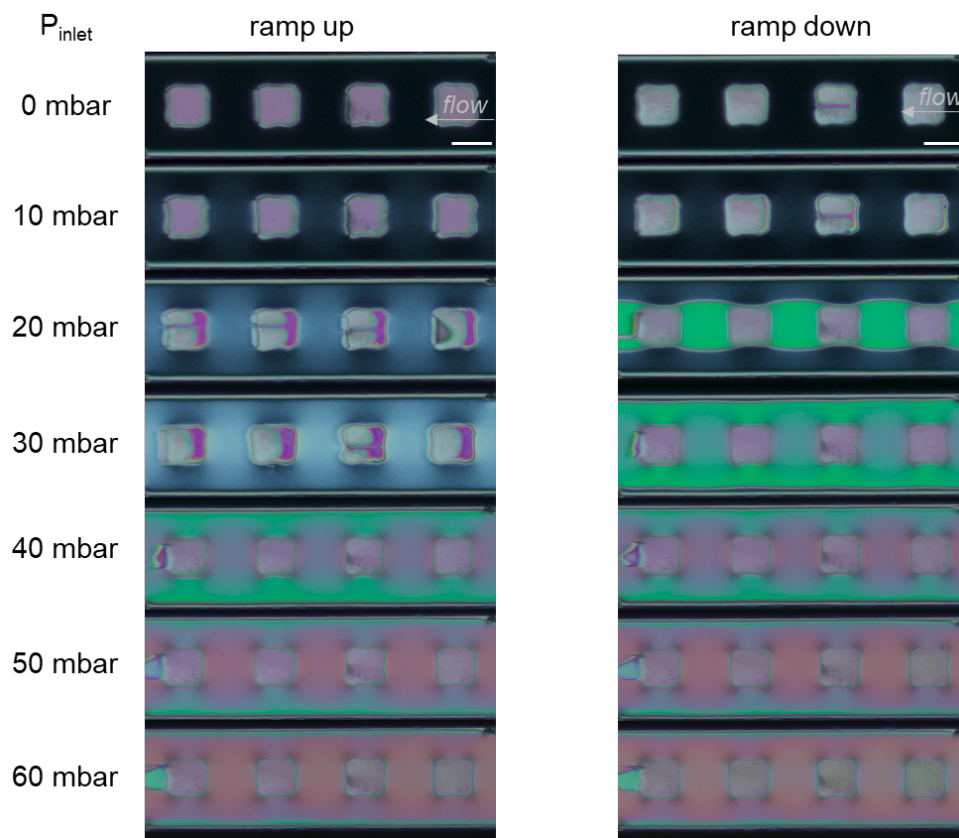
**Supplementary Note 9: Polarized optical microscopy observations of pressure-driven nematic 5CB flow under ramp-up and ramp-down inlet-pressure conditions for the three patterned microchannel models**



**Supplementary Figure 8.** Representative micrographs of flowing nematic 5CB in a channel patterned with Model 1 at the indicated inlet pressures in increasing (ramp up) and decreasing (ramp down) directions. The analyzer and polarizer are crossed at  $45^\circ$  and  $135^\circ$ . Scale bars:  $100\ \mu\text{m}$ .

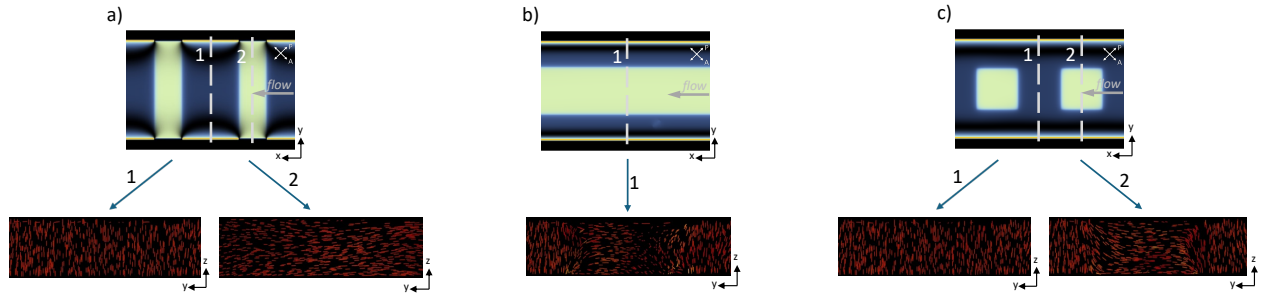


**Supplementary Figure 9.** Representative micrographs of flowing nematic 5CB in a channel patterned with Model 2 at the indicated inlet pressures in increasing (ramp up) and decreasing (ramp down) directions. The analyzer and polarizer are crossed at 45° and 135°. Scale bars: 100  $\mu\text{m}$ .



**Supplementary Figure 10.** Representative micrographs of flowing nematic 5CB in a channel patterned with Model 3 at the indicated inlet pressures in increasing (ramp up) and decreasing (ramp down) directions. The analyzer and polarizer are crossed at  $45^\circ$  and  $135^\circ$ . Scale bars:  $100\ \mu\text{m}$ .

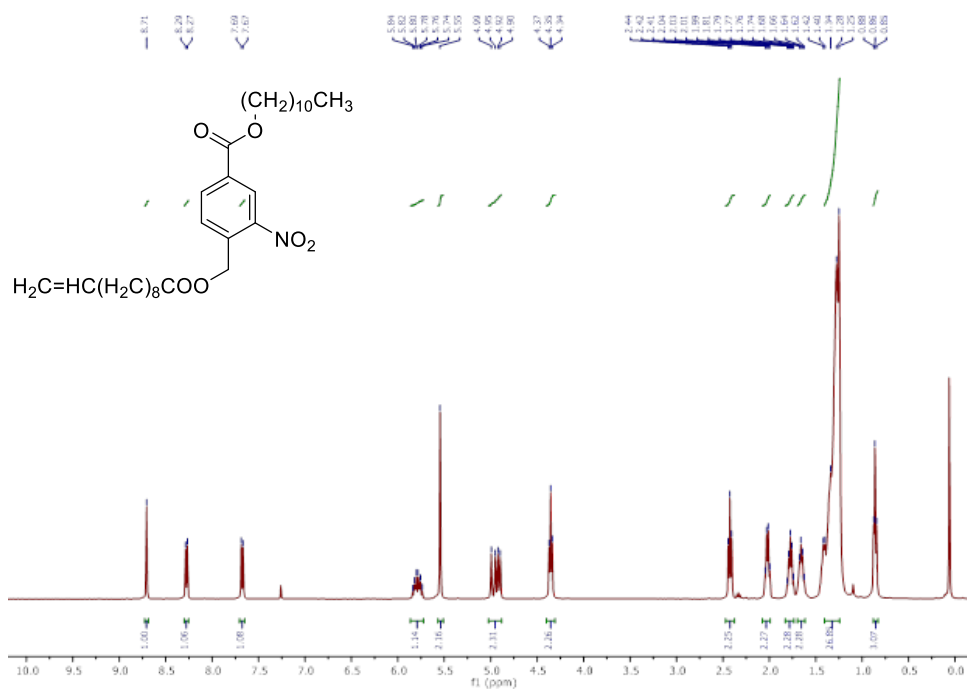
**Supplementary Note 10: Simulated cross-sectional director configurations in microfluidic channels with patterned anchoring**



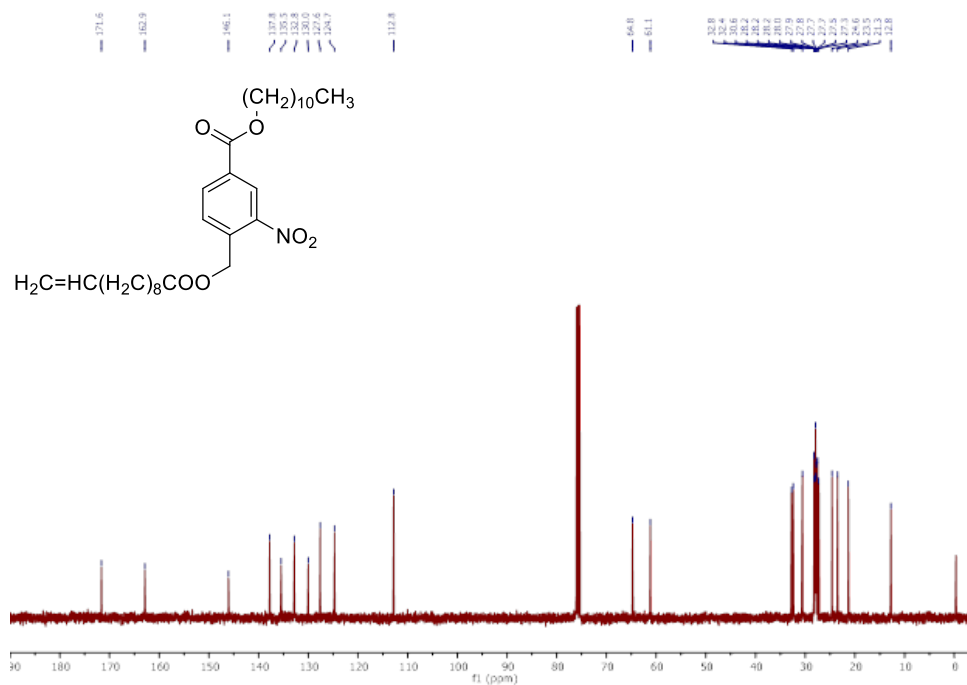
**Supplementary Figure 11.** Cross-section director configurations for the three patterned microchannel of Fig. 3: (a) Transverse pattern, (b) longitudinal pattern, and (c) square pattern. For each configuration, top-down simulated polarized optical microscopy images indicate the locations of the chosen cross-sections (dashed lines). The corresponding lower panels show the director field distribution in the  $y$ - $z$  plane perpendicular to the flow direction.

NMR result of the product labeled as 3 of the first reaction

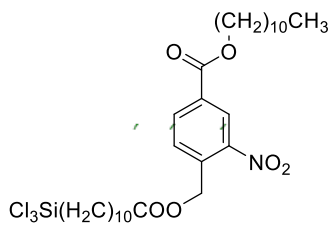




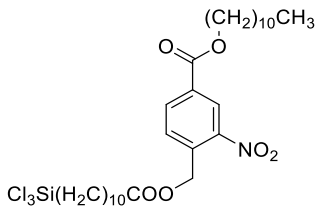
**Supplementary Figure 14.**  $^1\text{H}$  NMR spectrum of compound **2** in CDCl<sub>3</sub>.



**Supplementary Figure 15.**  $^{13}\text{C}$  NMR spectrum of compound **2** in CDCl<sub>3</sub>.

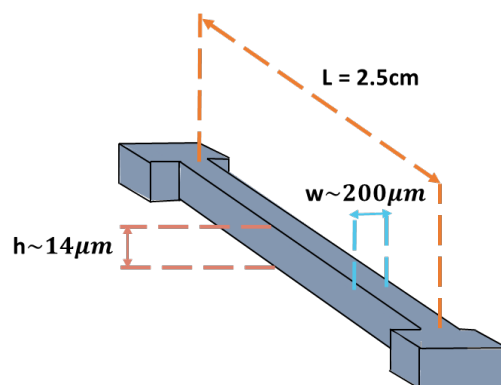


**Supplementary Figure 16.**  $^1\text{H}$  NMR spectrum of compound **3** in  $\text{CDCl}_3$



**Supplementary Figure 17.**  $^{13}\text{C}$  NMR spectrum of compound **3** in  $\text{CDCl}_3$ .

**Supplementary Note 12: Schematic of the experimental microfluidic channel dimensions**



**Supplementary Figure 18.** Schematic of the single-inlet, single-outlet straight microchannel geometry used throughout the experiments.

**Supplementary Note 13: The Average Velocities Corresponding to the Observed Tilt Angles Collected from Experiments of H-SAM Channels**

**Supplementary Table 4.** The measured average velocities corresponding to the observed tilt angles collected from experiments of H-SAM channels

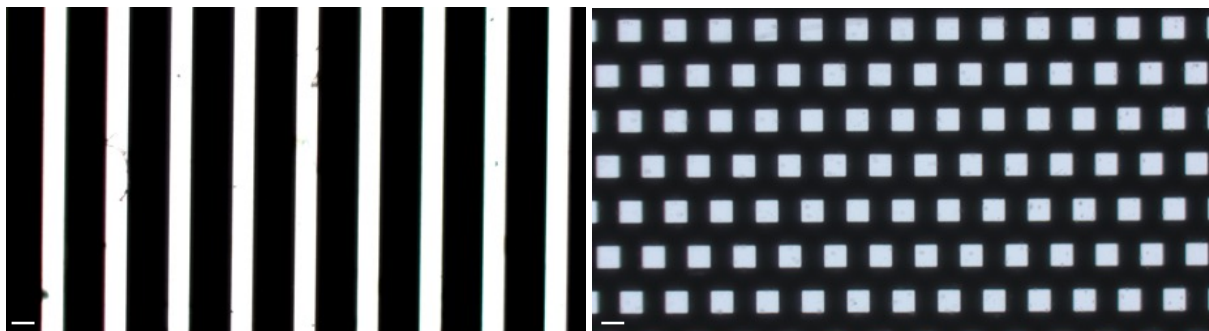
| <b>Tilt Angle</b> | <b>Average Velocity (<math>\mu\text{m/s}</math>)</b> |
|-------------------|------------------------------------------------------|
| 10                | 12.9                                                 |
| 12                | 21.6                                                 |
| 20                | 28.1                                                 |
| 25                | 39.8                                                 |
| 32                | 57.7                                                 |
| 35                | 72.3                                                 |
| 41                | 94.4                                                 |
| 45                | 116.2                                                |
| 52                | 127.3                                                |
| 62                | 138.5                                                |
| 79                | 209.1                                                |
| 79.4              | 245.5                                                |
| 80                | 258.5                                                |
| 81                | 261.8                                                |
| 82                | 294.8                                                |
| 84.8              | 313.1                                                |
| 86                | 395.1                                                |

**Supplementary Note 14: Fluorescence Confocal Polarizing Microscope (FCPM) Imaging Specifications**

**Supplementary Table 5.** The specifications for Fluorescence Confocal Polarizing Microscopy Imaging

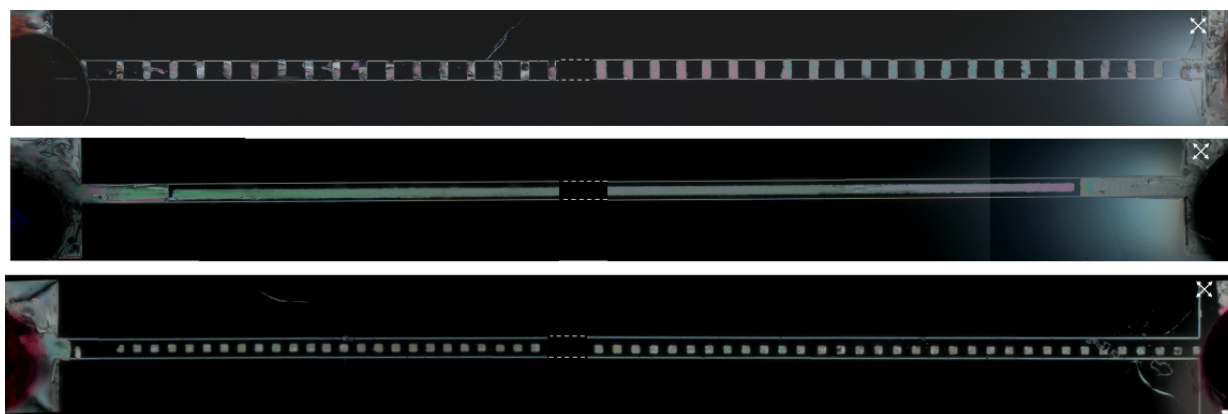
|                           | <b>Model 2</b>       |     |      |
|---------------------------|----------------------|-----|------|
| <b>Polarization Angle</b> | 0°                   | 45° | 135° |
| <b>Lens</b>               | 20x                  | 20x | 20x  |
| <b>Intensity</b>          | 3%                   | 5%  | 5%   |
| <b>Master gain (V)</b>    | 750                  | 800 | 730  |
| <b>Pinhole (μm)</b>       | 237                  | 237 | 237  |
|                           | <b>Model 1 and 3</b> |     |      |
| <b>Polarization Angle</b> | 0°                   | 45° | 135° |
| <b>Lens</b>               | 10x                  | 10x | 10x  |
| <b>Intensity</b>          | 3%                   | 5%  | 5%   |
| <b>Master gain (V)</b>    | 750                  | 800 | 750  |
| <b>Pinhole (μm)</b>       | 65                   | 65  | 65   |

**Supplementary Note 15: Masks used in H-SAM patterning**



**Supplementary Figure 19.** Microscopy images of the photomasks used in the study. Scale bars: 100  $\mu\text{m}$ .

**Supplementary Note 16: The polarized optical microscopy images of the top view of the patterned channels' appearance**



**Supplementary Figure 20.** The micrographs of the top views of the transverse, longitudinal, and square-patterned H-SAM modified channels are shown, respectively. The crossed analyzer and polarizer are oriented at  $45^\circ$  and  $135^\circ$ .