Electronic Supplementary Information

Building DC Electric Field-driven Wheat Leaf-like Surface Pattern with Cholesteric Liquid Crystal Fluoropolymer for Directional Droplet Manipulation

Deyan Li, [#, a, b] Zhijian Mai, [#, a, b] Yancong Feng, [#, a, b] Hui Min, [a, b] Jinglun Liao, [a, b] Yao Wang, [*, a, b] Hao Li, [*, a, b] and Guofu Zhou [a, b]

[a] *Guangdong Provincial Key Laboratory of Optical Information Materials and Technology & Institute of Electronic Paper Displays, South China Academy of Advanced Optoelectronics, South China Normal University, Guangzhou 510006, China*

[b] *National Center for International Research on Green Optoelectronics, South China Normal University, Guangzhou 510006, China*

[*]Corresponding should be addressed to:

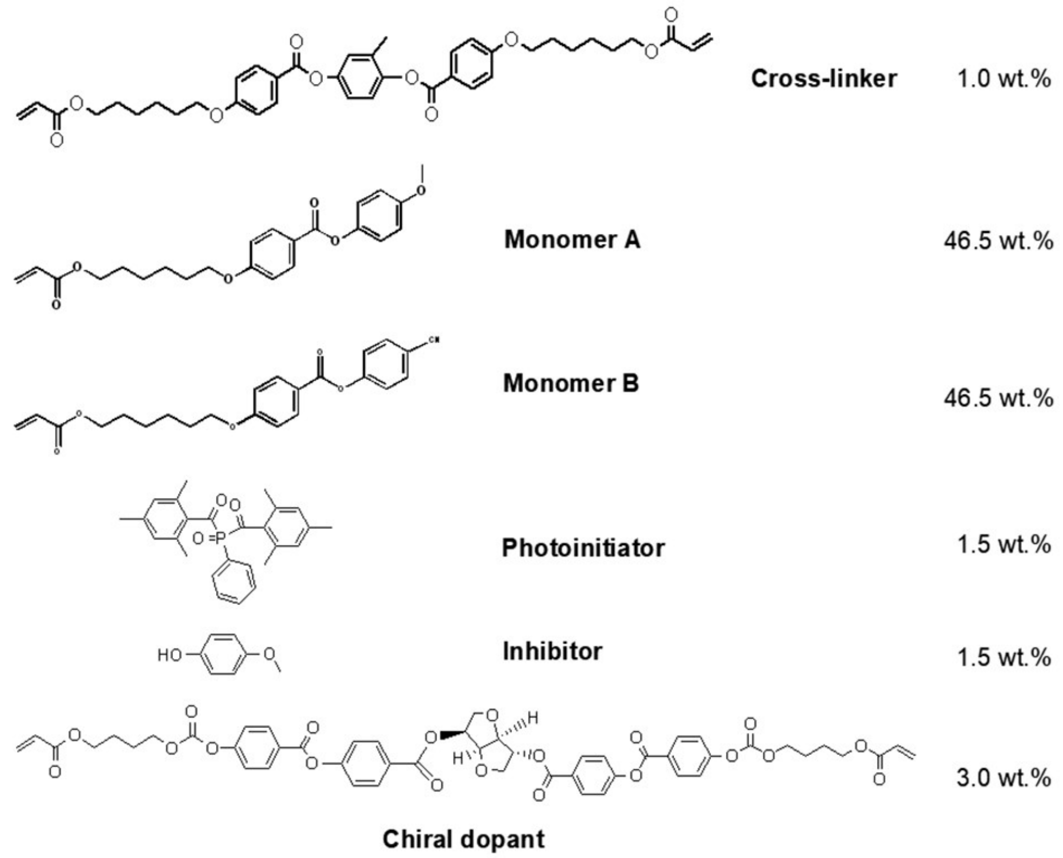
Associate Professor Hao Li; Tel: +86-20-39314813; Fax: +86-20-39314813

E-mail: haoli@m.scnu.edu.cn

Professor Yao Wang; Tel: +86-20-39314813; Fax: +86-20-39314813

E-mail: wangyao@m.scnu.edu.cn

[#]These authors contributed equally to this work.



Scheme S1 Chemical compositions of direct current (DC) electric field-driven fluorine-free cholesteric liquid crystal polymer (CLCP) coating.

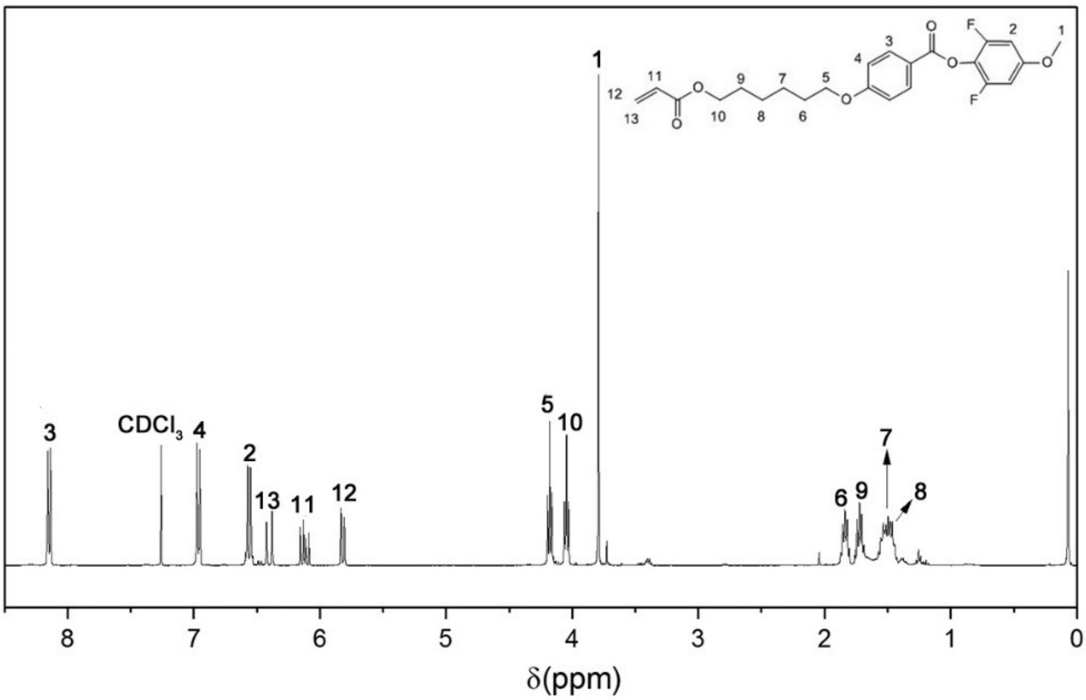


Fig. S1 ^{1}H-NMR spectrum of monomer A.

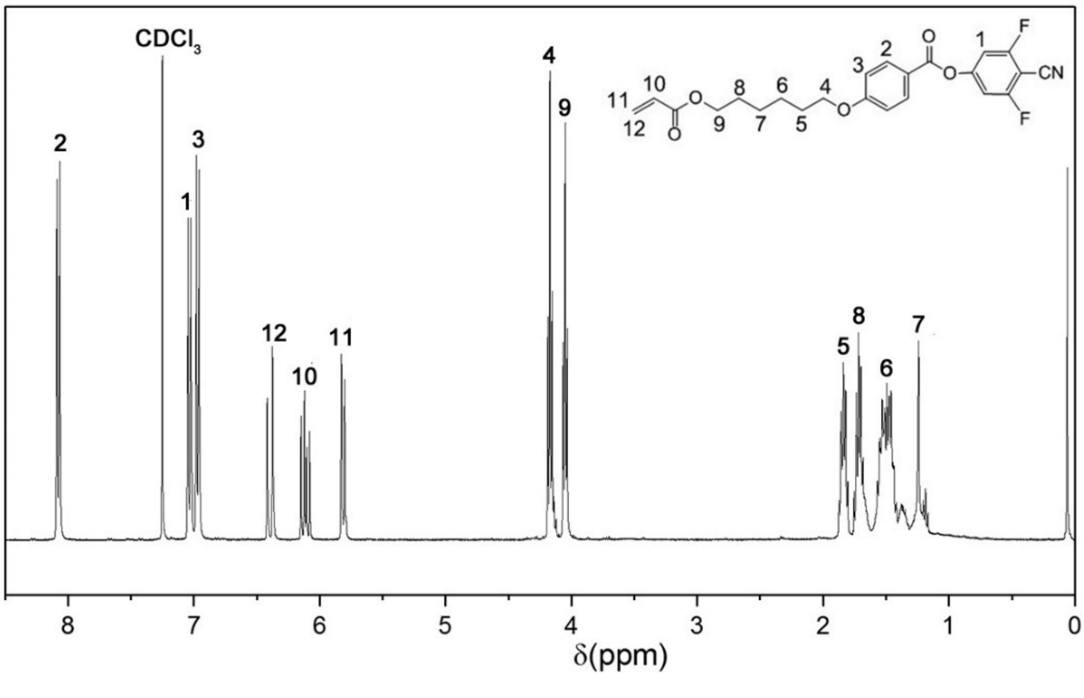


Fig. S2 ^{1}H-NMR of monomer B.

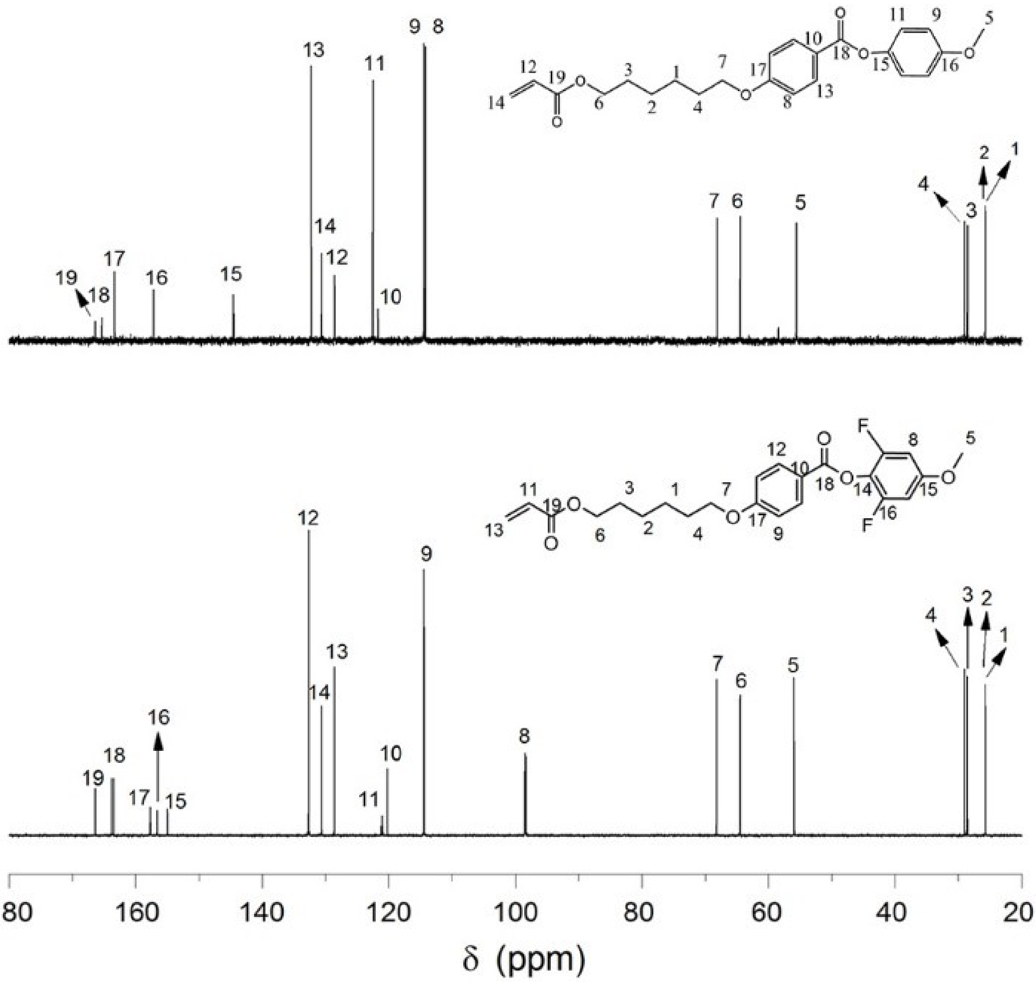


Fig. S3 Overlay ^{13}C-NMR spectra of monomer A and corresponding fluoride-free liquid crystal (LC) molecule (HCM-021).

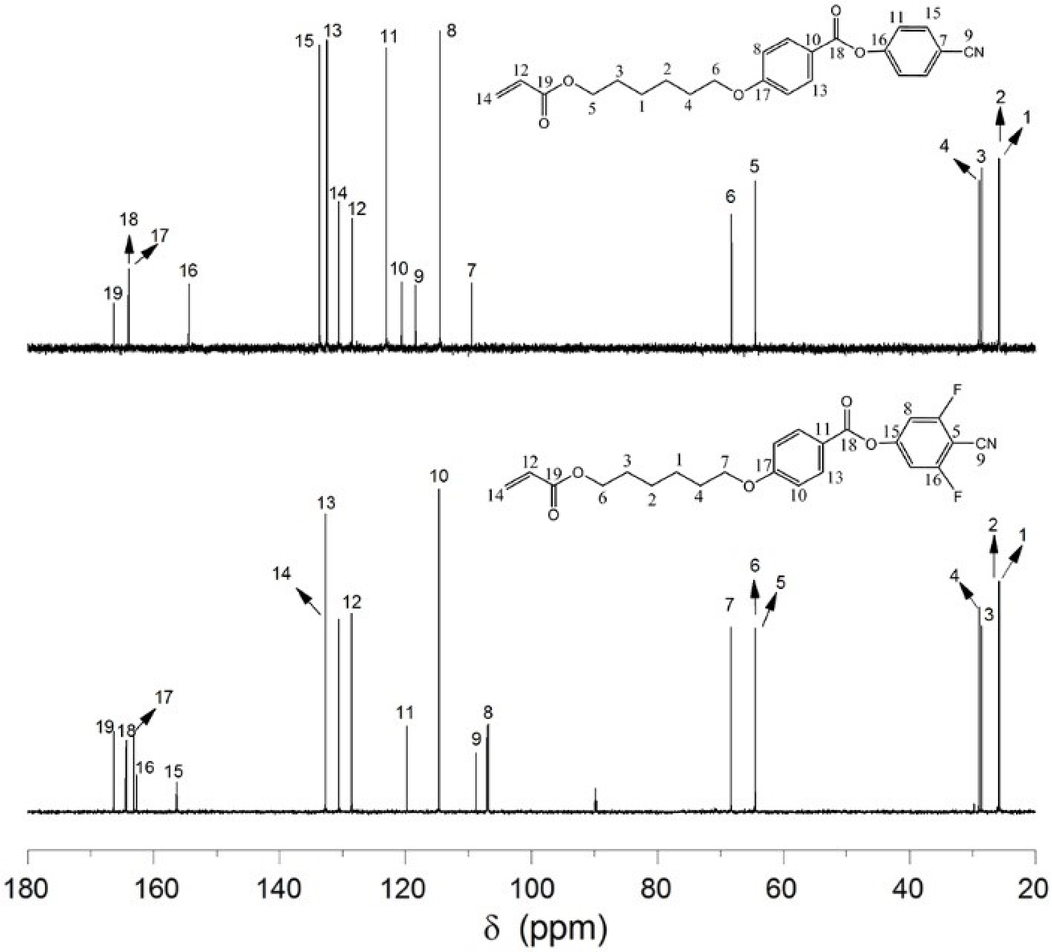


Fig. S4 Overlay ^{13}C-NMR spectra of monomer B and corresponding fluoride-free LC molecule (HCM-020).

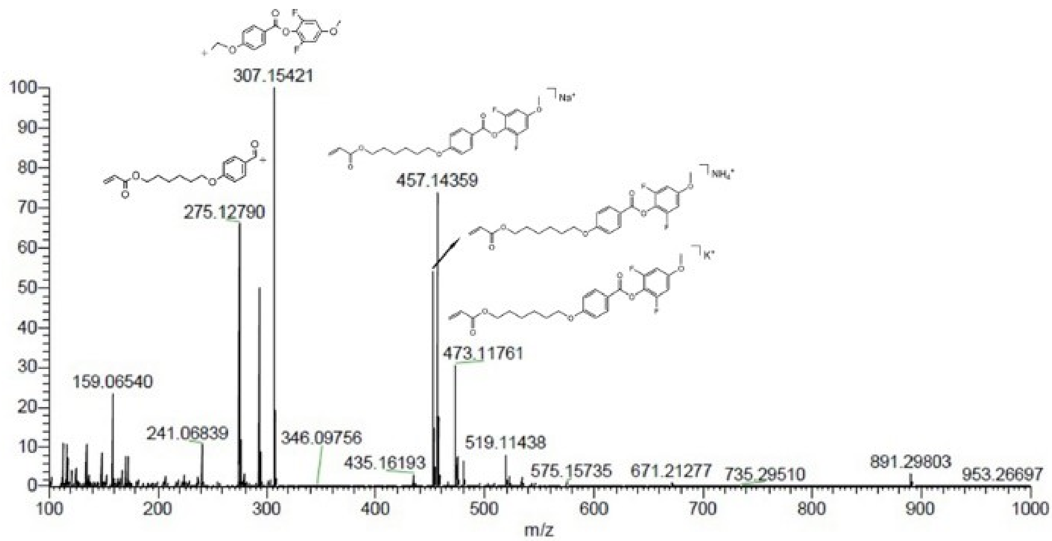


Fig. S5 Mass spectrum of monomer A.

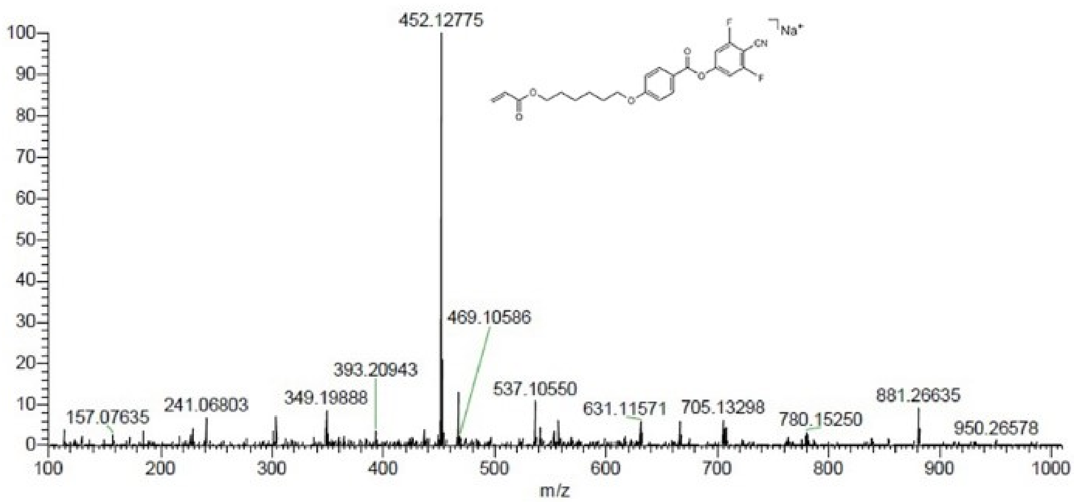


Fig. S6 Mass spectrum of monomer B.

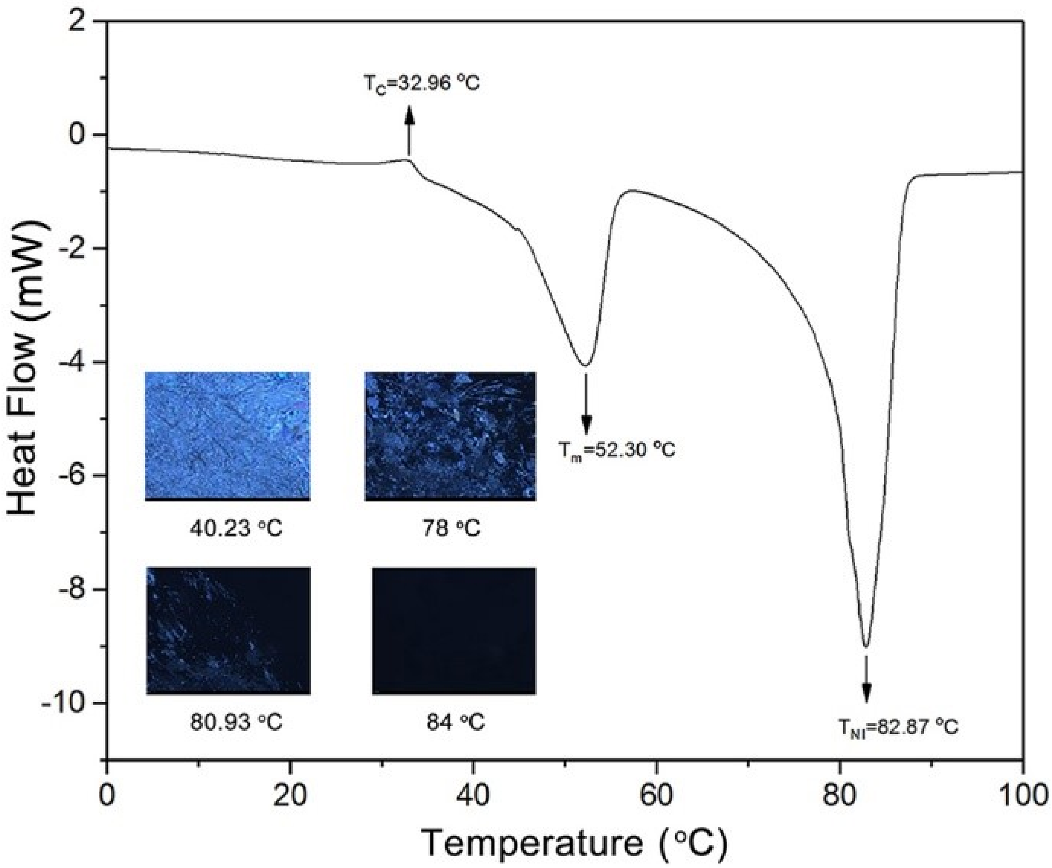


Fig. S7 Differential scanning calorimetry (DSC) curve of monomer A and corresponding polarizing optical microscope (POM) images at different temperatures. T_c=32.96 ^{o}C; T_m=52.30 ^{o}C; T_{NI}=82.87 ^{o}C.

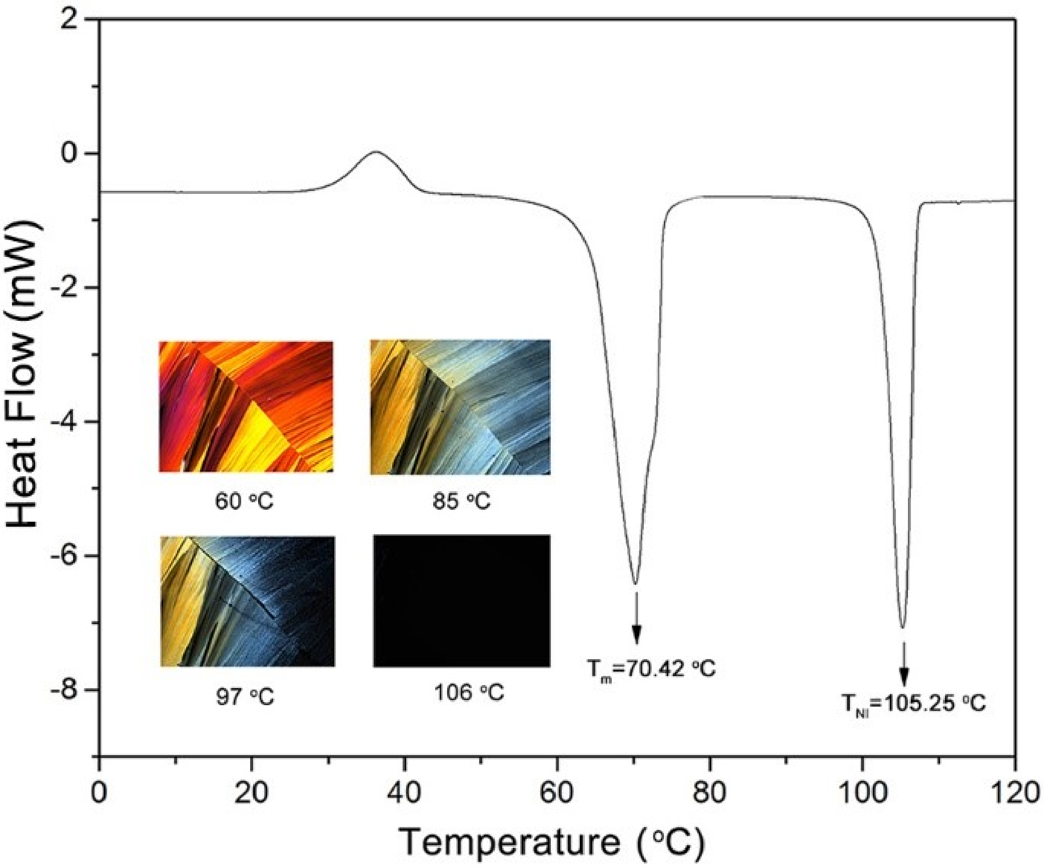


Fig. S8 DSC curve of monomer B and corresponding POM images at different temperatures. T_m=70.42 °C; T_{NI}=105.25 °C.

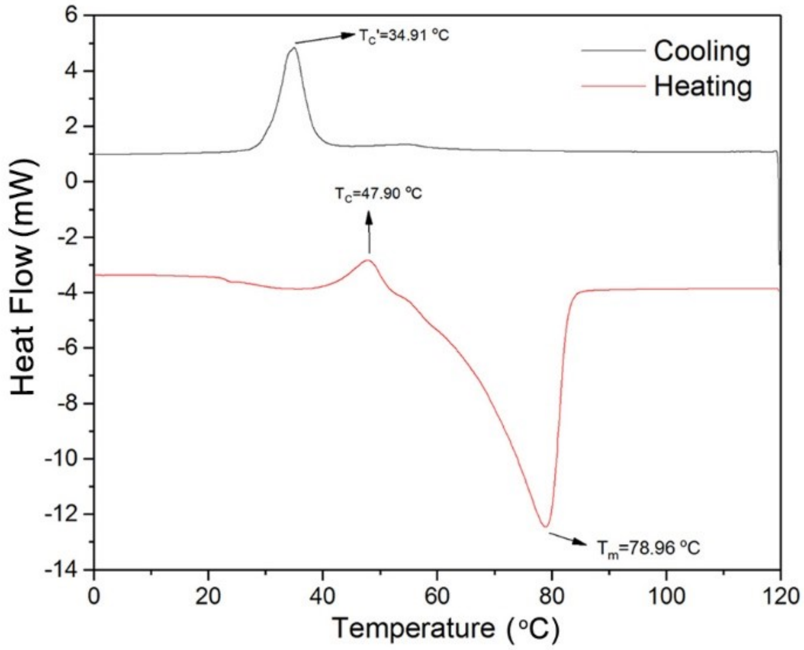


Fig. S9 DSC curves of the fluorinated LC mixture according to the formula in Table 1. T_c=34.91 °C; T_m=78.96 °C.

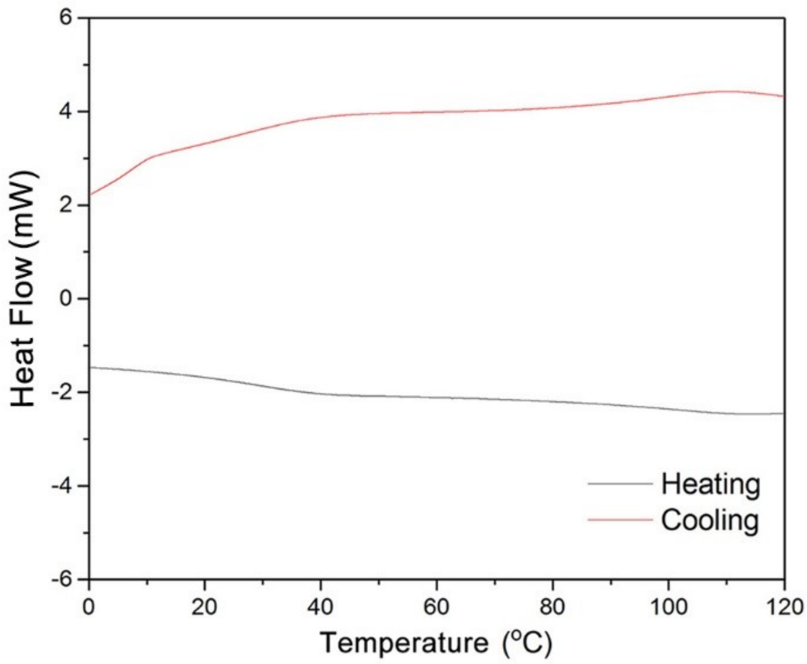


Fig. S10 DSC curves of the horizontally aligned CLCP coating with the thickness of 15 μm.

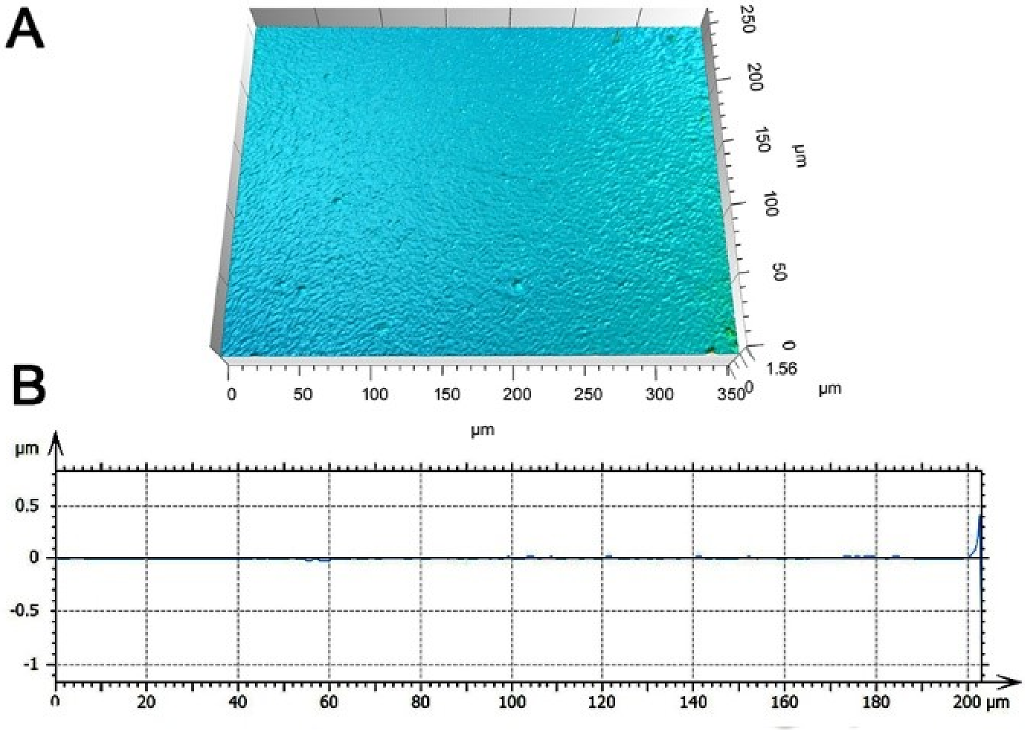


Fig. S11 Surface topography (amplification time: 50; A) and corresponding cross section curve (B) of horizontally aligned fluorinated CLCP coating with the thickness of 5 μm under applied DC electric field of 100 V (E=3.33 V·μm^{-1}) without predetermined heating treatment. **Notes:** This unheated CLCP coating is continuous and flat, indicating no response to the applied electric field.

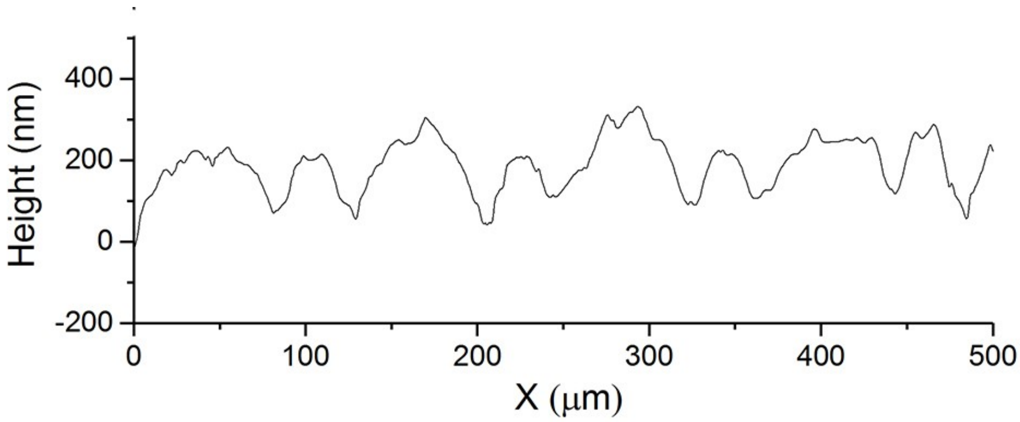


Fig. S12 Cross section curve of the horizontally aligned CLCP coating with the thickness of 15 μm at 50 °C under applied DC electric field of 100 V (E=3.33 V·μm^{-1}). (3 cm × 3 cm ITO substrate: gap, 30 μm; interval, 30 μm) **Notes:** The embossment height is about 250 nm.

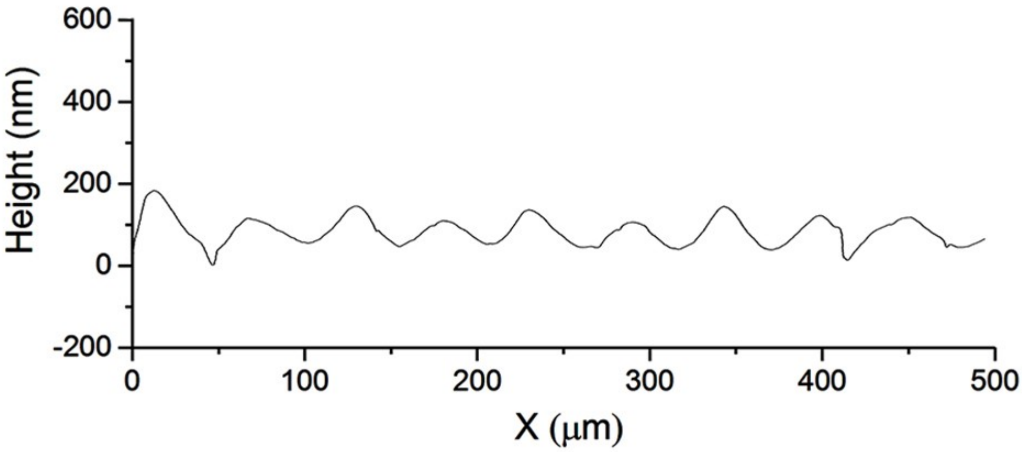


Fig. S13 Cross section curve of the horizontally aligned CLCP coating with the thickness of 35 μm at 50 °C under applied DC electric field of 100 V (E=3.33 V·μm^{-1}). (3 cm × 3 cm ITO substrate: gap, 30 μm; interval, 30 μm) **Notes:** The embossment height is less than 200 nm.

Fig. S14 The 3D surface topography (amplification time: 10) of the horizontally aligned CLCP coating with the thickness of 15 μm at 50 ^{o}C under applied DC electric field of 100 V (E=3.33 V·μm^{-1}). (3 cm × 3 cm ITO substrate: gap, 30 μm; interval, 60 μm) **Notes:** There are many regular, alternated strip embossments and valleys on the surface, in good accord with the pattern of the applied ITO substrate.

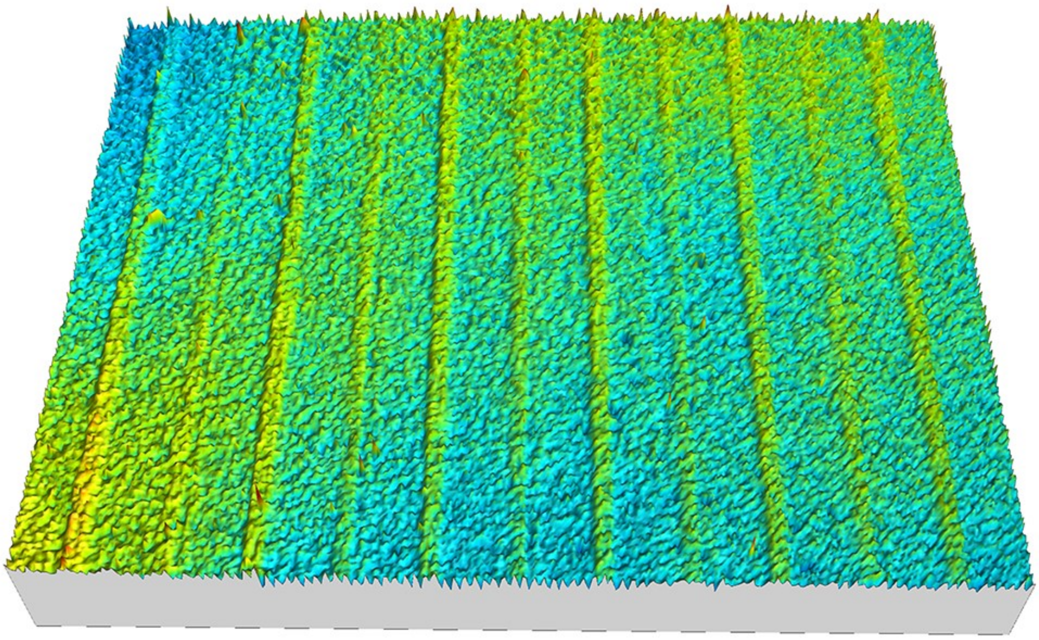


Fig. S15 The 3D surface topography (amplification time: 10) of the horizontally aligned CLCP coating with the thickness of 15 μm at 50 ^{o}C under applied DC electric field of 100 V (E=3.33 V·μm^{-1}). (3 cm × 3 cm ITO substrate: gap, 30 μm; interval, 120 μm) **Notes:** There are many regular, alternated strip embossments and valleys on the surface, in good accord with the pattern of the applied ITO substrate.

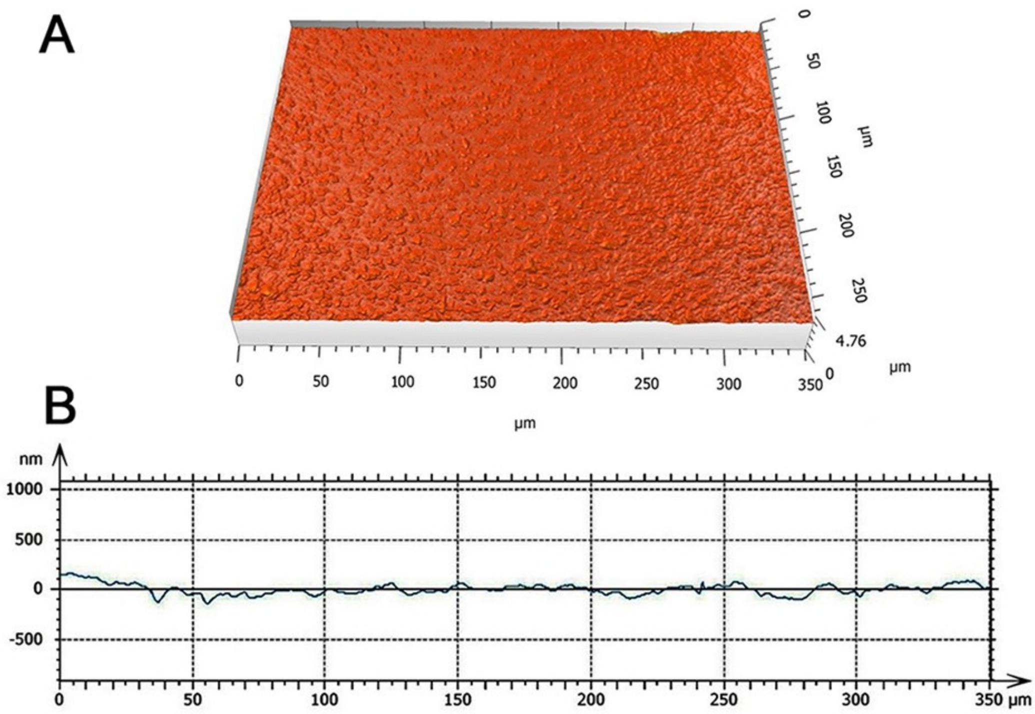


Fig. S16 The 3D surface topography (amplification time: 50) of the horizontally aligned fluorine-free CLCP coating with the thickness of 15 μm at 50 ^{o}C under applied DC electric field of 100 V [field strength (E): 3.33 V·μm^{-1}; A], and corresponding cross section curve (B). (3 cm × 3 cm ITO substrate: gap, 30 μm; interval, 30 μm) **Notes:** This CLCP coating is continuous and smooth with the fluctuation lower than 300 nm, indicating no response to the applied electric field.

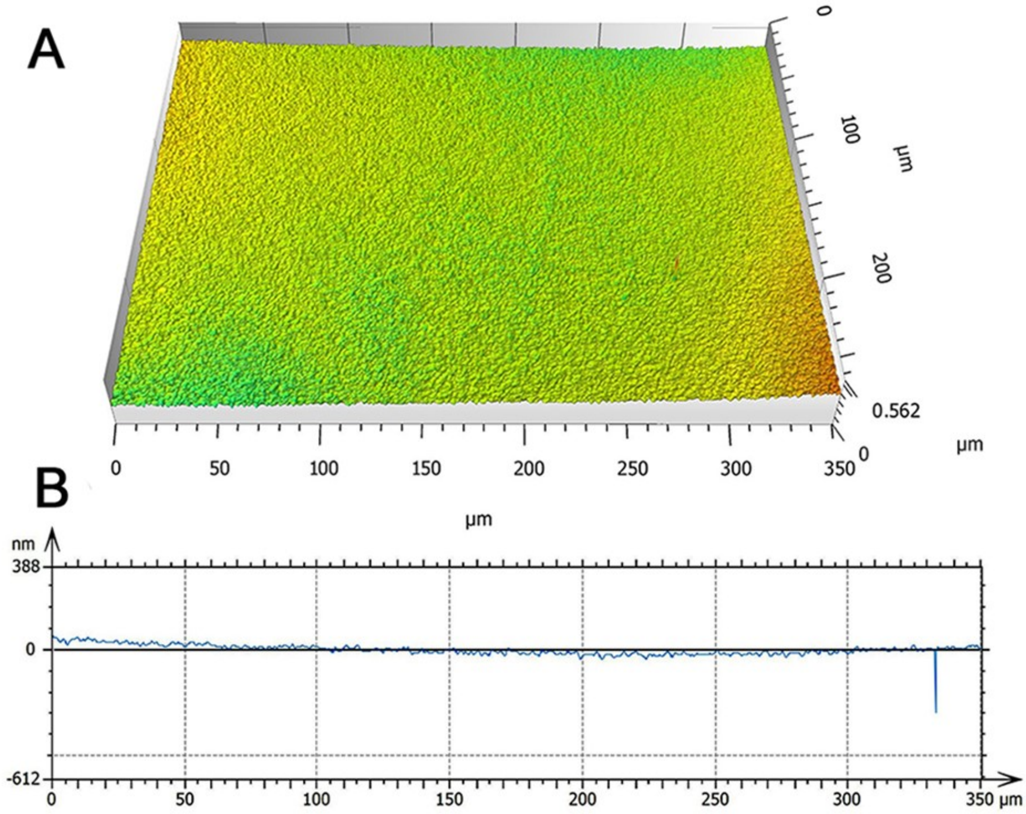


Fig. S17 The 3D surface topography (amplification time: 50) of the vertically aligned fluorine-free CLCP coating with the thickness of 15 μm at 50 ^{o}C under applied DC electric field of 100 V (E=3.33 V·μm^{-1}; A), and corresponding cross section curve (B). (3 cm × 3 cm ITO substrate: gap, 30 μm; interval, 30 μm) **Notes:** This CLCP coating is continuous and smooth with the fluctuation lower than 200 nm, indicating no response to the applied electric field.

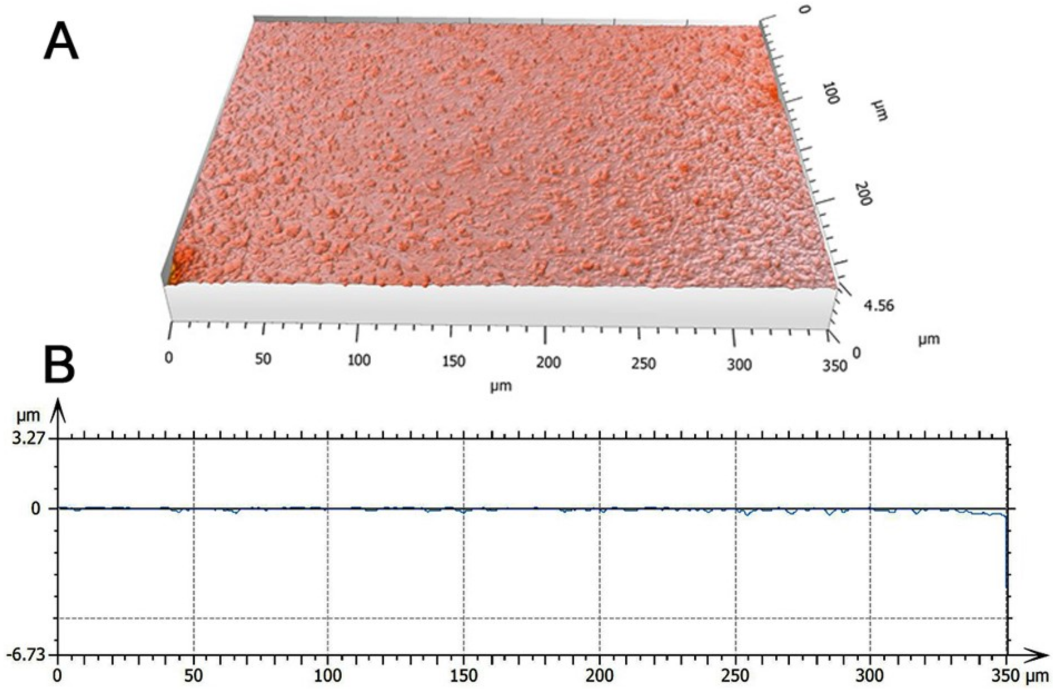


Fig. S18 The 3D surface topography (amplification time: 50) of the vertically aligned fluorinated CLCP coating with the thickness of 15 μm at 50 ^{o}C under applied DC electric field of 100 V (E=3.33 V·μm^{-1}; A), and corresponding cross section curve (B). (3 cm × 3 cm ITO substrate: gap, 30 μm; interval, 30 μm) **Notes:** This CLCP coating is continuous and smooth with the fluctuation lower than 100 nm, indicating no response to the applied electric field.

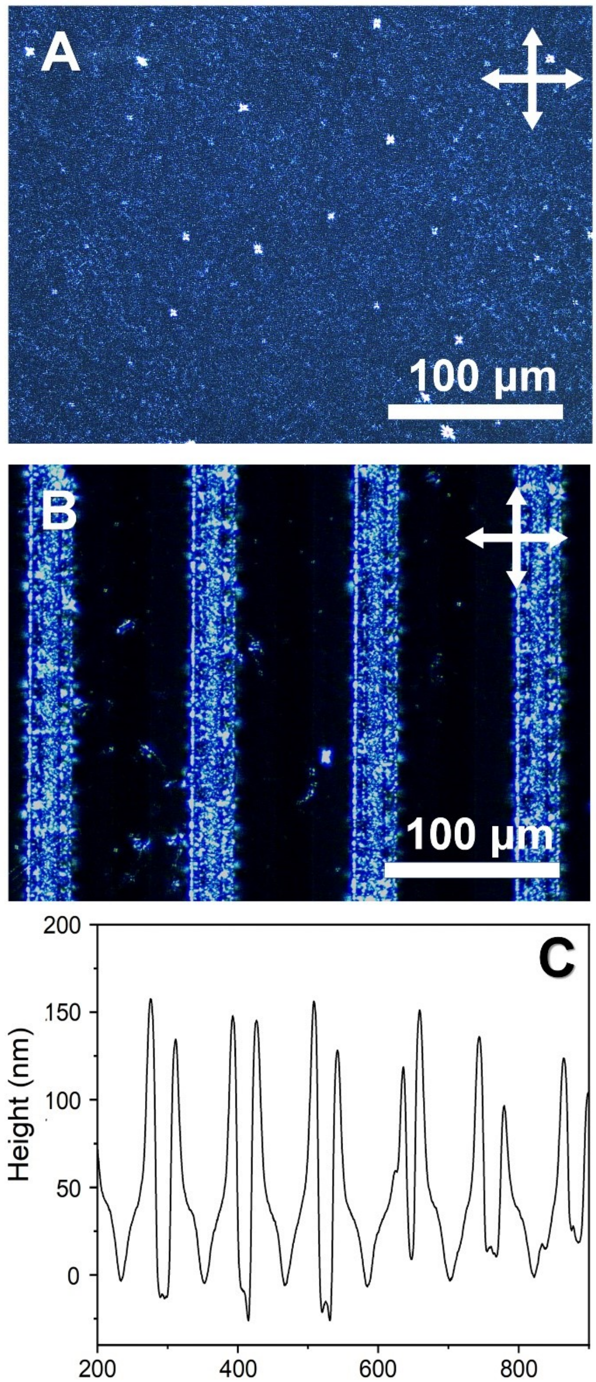


Fig. S19 AC electric field-responsive capabilities of horizontally aligned fluorinated CLCP coating with the thickness of 5 μm at 50 ^{o}C under applied AC field of 100 V (E=3.33 V·μm^{-1}) and 100 kHz: POM images before (A) and after electric actuation (B); corresponding cross section curve after electric actuation (C) (3 cm × 3 cm ITO electrode substrate: gap, 30 μm; interval, 60 μm).

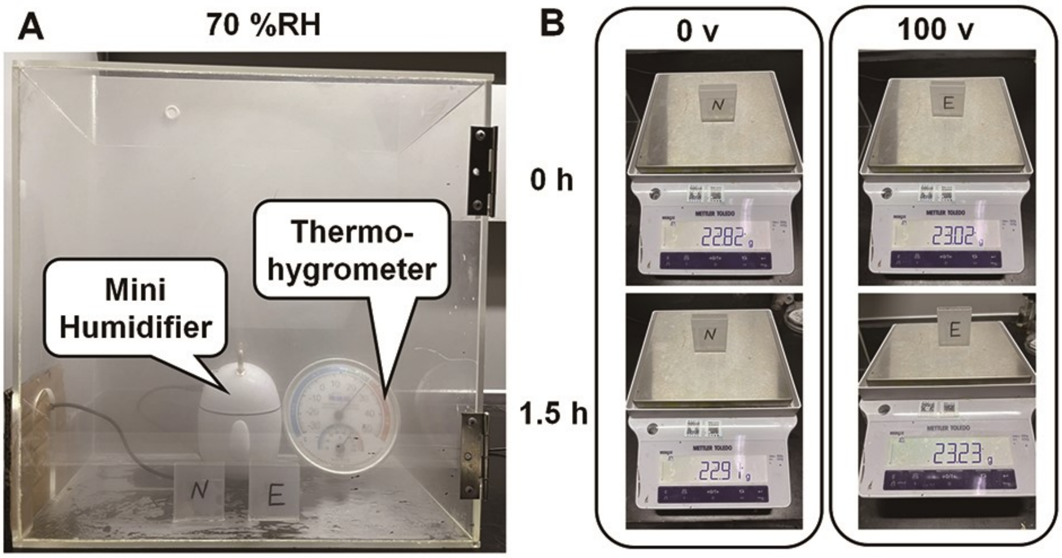


Fig. S20 Droplet condensation test of the horizontally aligned fluorinated CLCP coating with the thickness of 5 μm (3 cm × 3 cm ITO substrate: gap, 30 μm; interval, 30 μm) at 50 ^{o}C before and after DC electric field of 100 V applied (E=3.33 V·μm^{-1}): object pictures before (A1) and during the test (A2); object pictures of weighing the sample cuvettes before (B1 and B2) and after the test (B3 and B4). **Notes**: the word "N" on the surface of the cuvette, represents the unactuated sample; the word "E" on the surface of the cuvette, represents the actuated sample.

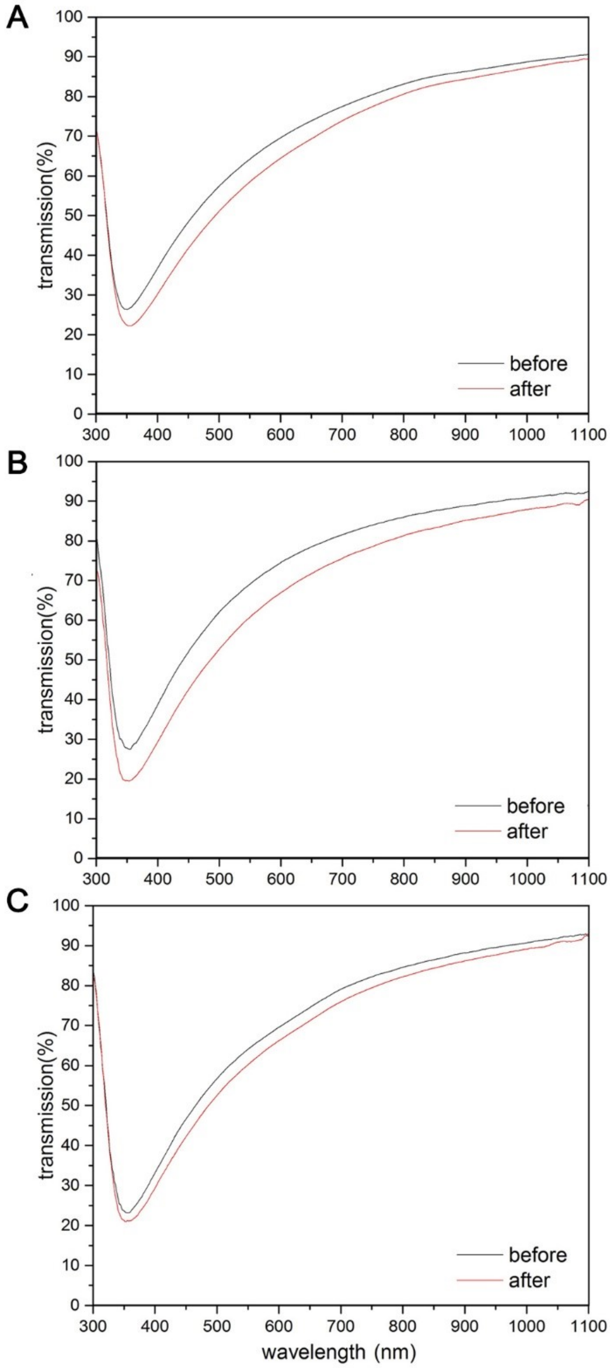


Fig. S21 Transmittance curves of the horizontally aligned fluorinated CLCP coating with the thickness of 5 μm at 50 °C before and after DC electric field of 100 V applied (E=3.33 V·μm^{-1}). (3 cm × 3 cm ITO substrate: gap, 30 μm; interval, 30 μm (A), 60 μm (B) and 120 μm (C)).

Table S1 Comparison of the electric field-responsive capabilities of the reported LC systems.

Reference	[29]	[30]	[31]	[36]	This work
Type of Electric Field	AC	AC	AC	DC	**DC**
Type of LC systems	Cross-linked Polymer	PDMS mixture	Cross-linked Polymer	Non-crosslinked oligomer	**Cross-linked Polymer**
Type of Driving Mode	One-side	One-side	One-side	Two-side	**One-side**
Minimum Field Strength Required for Response (V•μm^{-1})	~4.00	6.25	16.10	~	**1.67**
Applied Field Strength Required for Response (V•μm^{-1})	7.50	15.00	20.00	57.14	**3.33**
Maximum Embossment Height (μm)	0.15	0.15	0.30	~2.5	**0.50**
Coating Thickness (μm)	2.50	8.00	4.00	2.8	**5.00**
Deformation Index (DI)	6.00%	1.875%	7.50%	89.29%	**10.00%**

Notes: AC and DC denote alternated current and direct current, respectively.

Video S1 Wall droplet test of the horizontally aligned fluorinated CLCP coating with the thickness of 5 μm at 50 ^{o}C under applied DC electric field of 100 V. (3 cm × 3 cm ITO substrate: gap 30 μm; interval 30 μm). (see the attached video file named "**Video S1**")

Video S2 Wall droplet test of the horizontally aligned fluorinated CLCP coating with the thickness of 5 μm at 50 ^{o}C under applied DC electric field of 100 V. (3 cm × 3 cm ITO substrate: gap 30 μm; interval 30 μm), using unactuated sample as control (see the attached video file named "**Video S2**")