SUPPORTING INFORMATION

Fabrication of a high-performance thin film polarizer using lyotropic chromonic liquid crystals using a high-resolution nanoscale template

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Will be added

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NMR spectroscopy of PDI-HCl

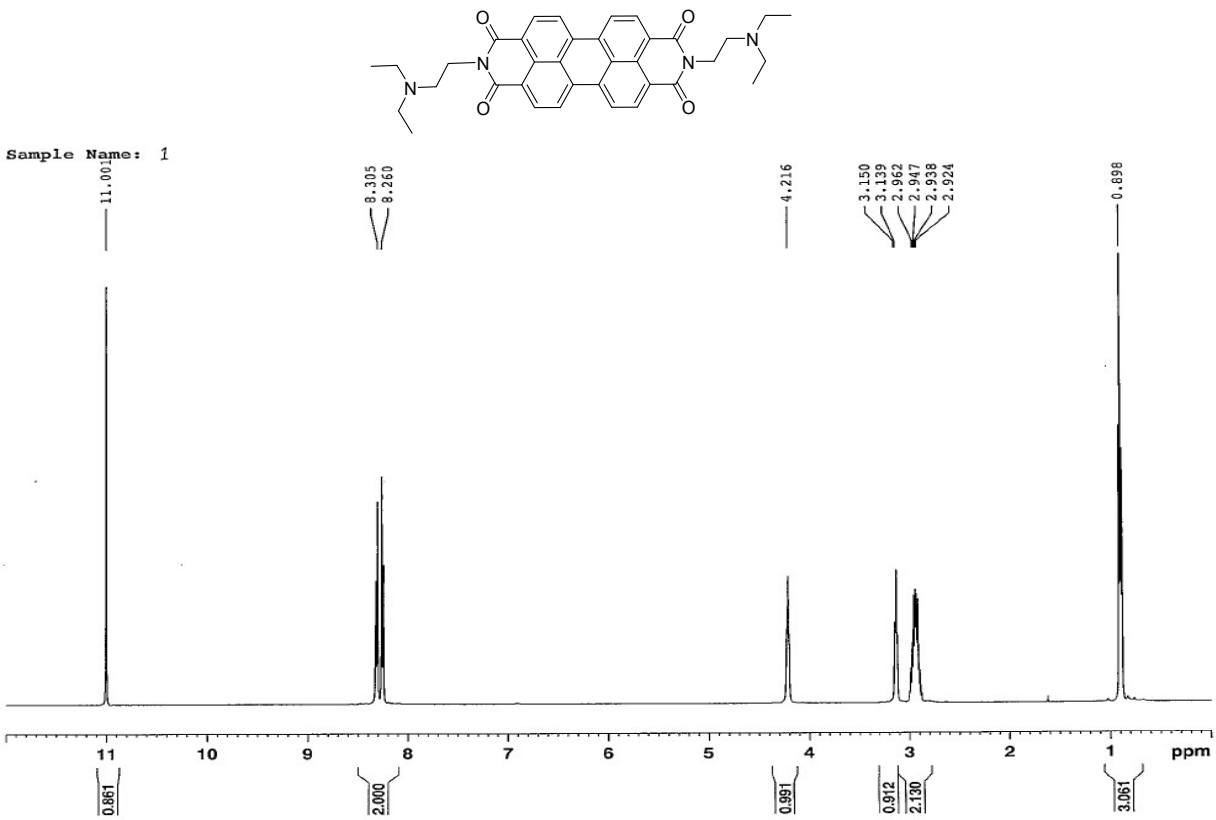

Figure S1: NMR spectroscopy of PDI-HCl (400MHz 1H-NMR, in CF3COOD) : δ 8.34 (d, 4H), 8.287 (d, 4H), 4.216 (m, 4H), 4.232 (m, 4H), 2.952 (m, 4H), 0.911 (m, 4H)

POM image of 15% PDI-HCl solution on glass

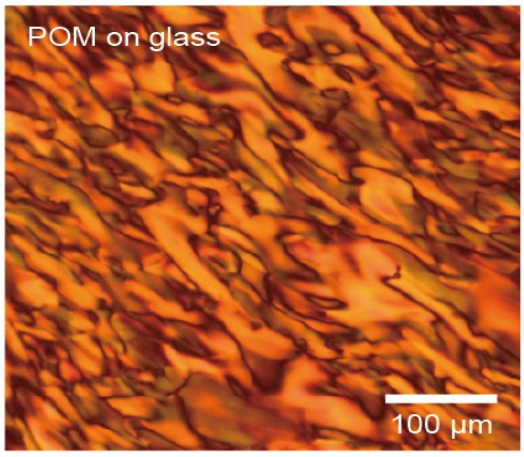

Figure S2: POM image of 15% PDI-HCl solution on glass. PDI-HCl forms columnar aggregates (chromonic namatic (N) phase) over 7 wt% concentration.

Cross-sectional image of ITO nano pattern

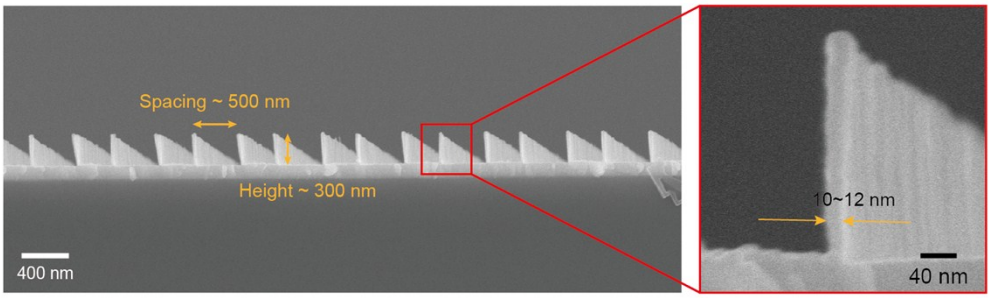

Figure S3: SEM image of ITO nanopattern. Secondary sputtering lithography can make high resolution (~10 nm) pattern.

Polarizer performance of LCLC sandwiched cell with various *q*A

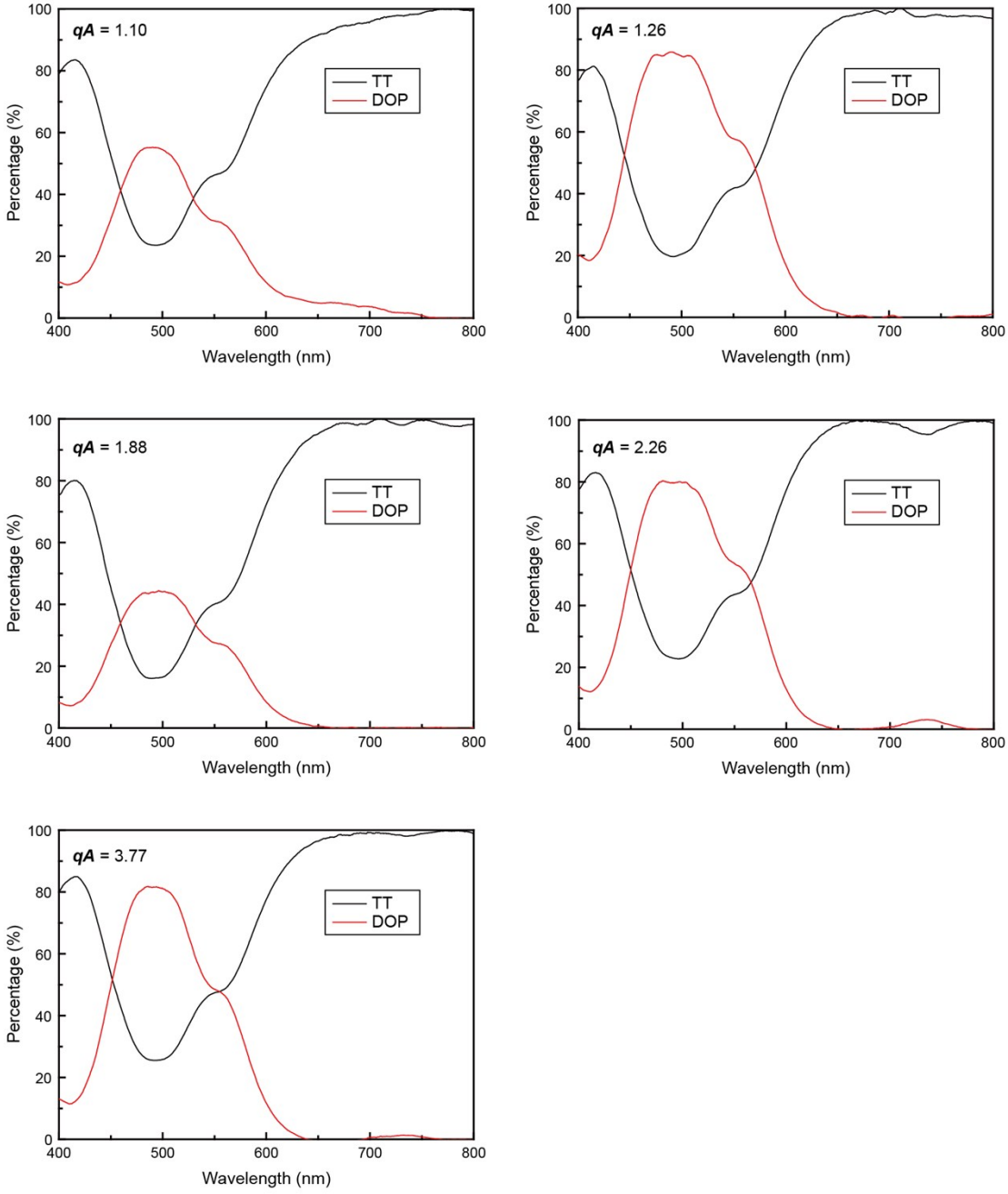

Figure S4: Total transmittance (TT) and degree of polarization (DOP) of of LCLC sandwiched cell with various *qA*. As qA (q=2π/λ) increases, T_0 was slightly increased and T_{90} was slightly decreased until $qA \sim 2$. Which lead to increase of DOP.

By the change of array pitch and wall height, we prepared sample with various qA value various. Three array pitch (500nm, 1um, 2um) and wall heights (200nm, 400nm, 600nm) were prepared. Effective wall height of each sample was confirmed by AFM.

Array pitch (nm)	Wall height (nm)	*q*A
500	87.5	1.1
500	180	2.26
500	300	3.77
1000	300	1.88
2000	400	1.26

TT and DOP was measured within sandwiched cell with varying *qA*.

qA	Average	
	TT	DOP
1.10	24.58	56.13
2.26	33.14	69.24
3.77	16.91	79.85
1.88	24.89	75.38
1.26	23.42	21.50

Scheme of determine polarizer performance with UV spectrophotometer

We determined polarizer performance with UV spectrophotometer. Three different area - shearing only (i), shearing + parallel nanoscale array(ii) and shearing + cross nanoscale array(iii) - are exist in single ITO glass after coating. T0 is the value that when the shearing direction of LCLC polarizer was placed parallel to transmission axis direction of analyzer, and T_{90} is the value that when the shearing direction of LCLC polarizer was placed perpendicular to transmission axis direction of analyzer. Using these to value T_0 and T_{90}, total transmittance and degree of polarization were calculated.

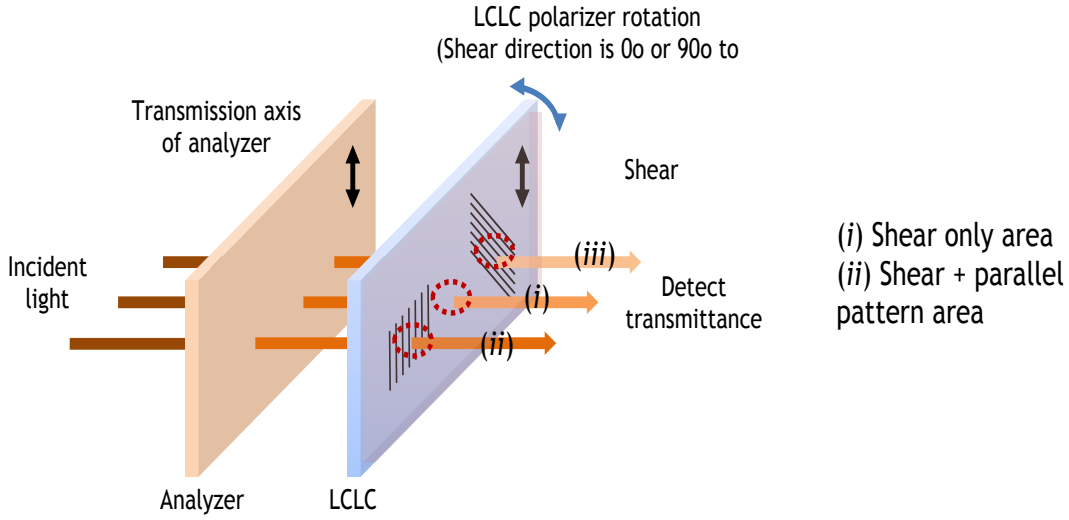

Figure S5: Method for polarizer performance with UV spectrophotometer. According to LCLC polarizer rotation, T_0 and T_{90} were obtained

Photographs of LCLC polarizer sample with combined method

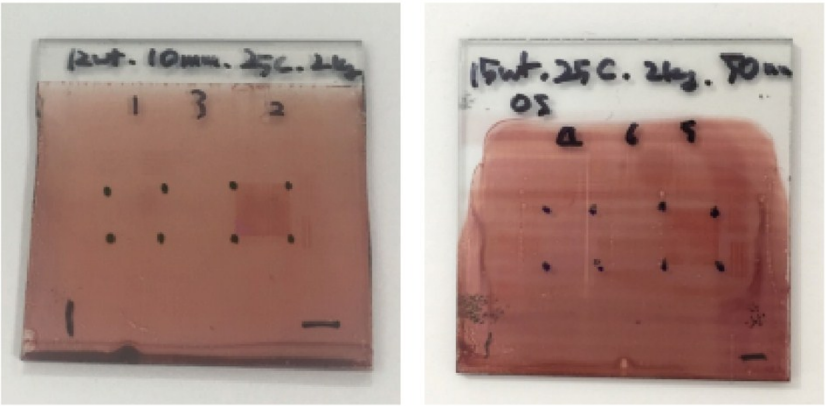

Figure S6: Photographs of coated sample. In each sample, left area is parallel nano-array pattern with coating direction and right area is cross nano-array pattern with coating direction. Cross nano-array patterned area has more dark color because of low total transmittance.

Polarizer performance with low concentration

PDI-HCl forms columnar aggregates (chromonic namatic (N) phase) over 7 wt% concentration. But in the combined method, 6% and 8% solution does not show the enough polarizer performance. Also, TT / DOP for shearing // parallel nanoscale array (ii) and shearing ⊥ nanoscale array (iii) almost same value, and higher than mechanical shearing only area (i). Which means, in the low concentration, LCLC align by mechanical shearing is not effective.

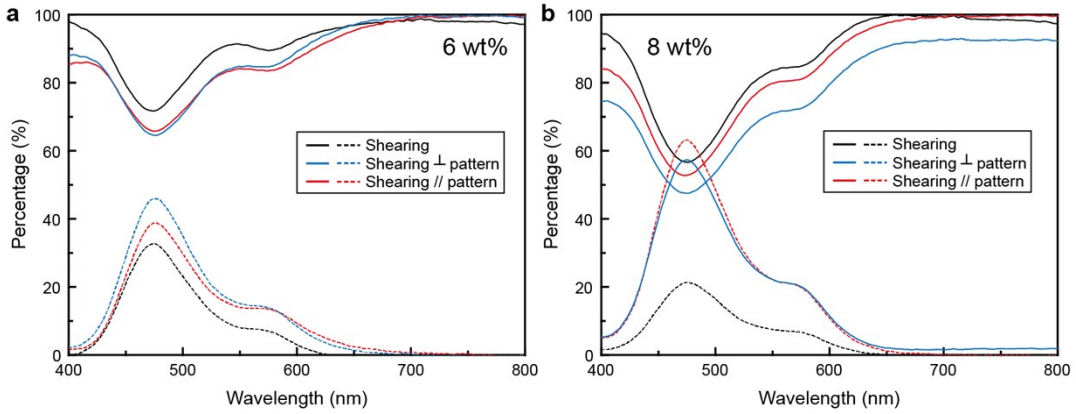

Figure S7: Comparing total transmittance and degree of polarization in low concentration.

POM image of each area with 15wt% solution

Shearing // pattern area was most bright than the other areas when the shearing direction is parallel to analyzer direction. Shearing // pattern area was most dark than the other areas when the shearing direction is cross to analyzer direction. Unlike 10wt% solution (Figure 3b), color inversion was not seen in shear ⊥ pattern area in 15% solution.

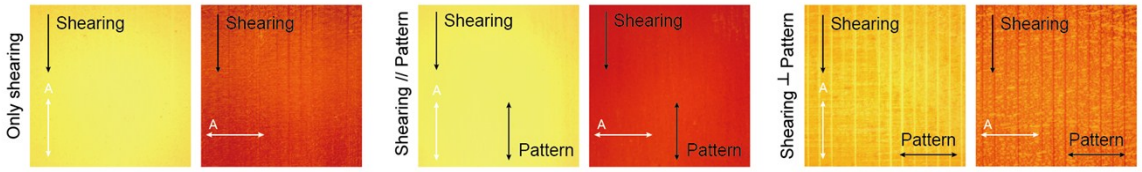

Figure S8: POM image of each area with 15wt% solution.

Polarizer performance of LCLC polarizer with concentrations

As the LCLC concentration increased, DOP was increased. In each test condition, shear // nano-array pattern area show the highest result than the other areas. Minus value in DOP of shear ⊥ pattern area under low concentration (below 10wt%) means $T_{90} > T_0$, also indicate that LCLC align direction is along with nano-array pattern direction.

Concentrations	Areas	TT	DOP
6wt%	shear	**71.73**	**32.71**
	shear + parallel	**65.74**	**38.78**
	shear + cross	**64.55**	**-45.92**
8wt%	shear	**56.61**	**21.35**
	shear + parallel	**52.75**	**63.18**
	shear + cross	**47.47**	**-57.30**
10wt%	shear	**51.08**	**56.59**
	shear + parallel	**44.91**	**80.48**
	shear + cross	**41.99**	**-68.81**
12wt%	shear	**44.37**	**89.28**
	shear + parallel	**40.68**	**93.23**
	shear + cross	**18.94**	**7.67**
15wt%	shear	**36.30**	**92.09**
	shear + parallel	**41.92**	**98.59**
	shear + cross	**23.92**	**63.65**
15wt% -change coating	shear	**40.92**	**98.37**
	shear + parallel	**40.62**	**99.47**
	shear + cross	**14.02**	**73.08**

Table S9: Polarizer performance table for various concentrations.

Polarizer performance of LCLC polarizer with temperatures

As the coating temperature increased, DOP was decreased. Minus value in DOP of shear ⊥ pattern area under high temperature (35℃) means T90>T0, also indicate that LCLC align direction is along with nano-array pattern direction.

Temperatures	Areas	TT	DOP
15℃	shear	**42.17**	**90.58**
	shear + parallel	**42.69**	**95.75**
	shear + cross	**20.91**	**21.07**
25℃	shear	**44.37**	**89.28**
	shear + parallel	**40.68**	**93.23**
	shear + cross	**18.94**	**7.67**
35℃	shear	**36.18**	**52.73**
	shear + parallel	**46.77**	**90.78**
	shear + cross	**23.43**	**-22.62**

Table S10: Polarizer performance table for various temperatures.

Microscopic view of coating surface POM images of coated surface

Figure S10a shows many micro-cracks and stains which indicated partially disordered LCLC in mechanical shearing only area. Micro-cracks were easy to be created on shearing direction because large volume shrinkage was occurred during solvent evaporation process. Stains were originated from non-uniform LCLC coating because of high surface tension of aqueous LCLC solution. Whereas no defects were observed in the area of shearing and nano-array pattern combined area. (**Figure S10b**) Especially, when we created collapsed region intentionally, only collapsed area had micro-cracks and patterned area showed clear image. From these results, we can know coating defects can be suppressed through LCLC holding by anchoring effect of nano-array pattern during solvent evaporation.

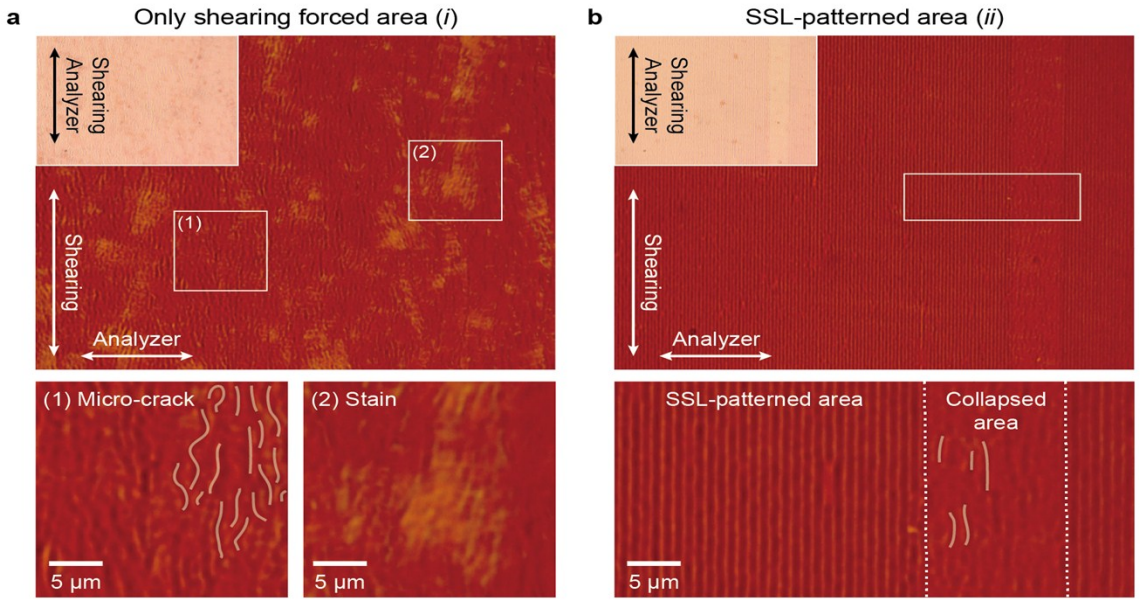

Figure S11: POM images of coated surface (a) Shearing only area. Many stains and micro-cracks were seen in magnified image of cross analyzer direction. (b) Shearing and parallel nano-array pattern area. Many micro-cracks were seen in Nano-array pattern collapsed area, whereas no micro-cracks in nano-array pattern area.