Supplemental material

Tuning of Photonic Band Gap via Combined effect of Electric and Optical fields in a Blue Phase Liquid Crystal composite

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**S1. Chemical structures**

***Figure S1:*** *Chemical structures and phase transition temperatures of the components used for the BP mixtures.*

**S2. Temperature-concentration phase diagram**

**S3. Lattice reorientation with electric and optical field**

***Figure S2:*** *Temperature vs concentration (of S811) phase diagram of the BP system with BLC concentration fixed at 15 wt%.*

In BPI there are four prominent selective reflection planes (110), (200), (211) and (220). The ratio of λ for selective reflection from these planes[Ref.S1] (in the same order given above) is 1: 1/√2 :1/√3 :1/2.

 In the BP38E0.3 mixture, the ratio between the λ values obtained with the fields of 6.3 V/ μm and 6 V/ μm is 1.4, which matches with the ratio for (200) :(220) planes (*i.e.,* √2). Hence, it is clear that, up to a field of 6 V/ μm, the (220) plane is normal to the incident light and for 6.3 V/ μm, the plane reorients to (200), which is the most stable one against electric field.

Similarly, for the BP25E0.3 mixture, as the electric field is increased from 1 V/ μm to 2.6 V/ μm, the λ value decreases from 677 nm to 586 nm. The ratio of the λ value in the two field driven states is 1.16. As mentioned above, the ratio between the λ values of (110) and (200) planes is √2. Hence, it can be argued that, the BPI lattic plane reorients from (110) normal to the incident light, towards (200).

**S4. UV-Visible spectroscopy**

 ***Photo-isomerization quantum yield***

Azobenzene molecule is known to exhibit absorption in the UV (~ 365nm) and visible (~ 450 nm) wavelength range, which correspond to the π-π\* transition of the trans- isomers and n- π\* transition of the *cis-* isomers respectively [Ref.S2]. Hence, a decrease in the intensity of the π-π\* absorption peak is an indication of *trans-* to *cis-* isomerization.

Accordingly, UV-visible spectroscopy is carried out on the BP38E0.3 and BP25E0.3 mixtures at a temperature of 2 oC below the Iso (or BPII) – BPI transition in pristine and UV irradiated conditions. The UV power used is 0.05 mW/cm2 and the duration of illumination is kept as the time required for the maximum wavelength shift (obtained from selective reflection studies). The sample is sandwiched between quartz plates with the sample thickness being ~ 13 μm. The spectra are recorded using UV-visible spectrometer (*Perkin Elmer - Lambda750*), with a spectral resolution of 1 nm.

***Figure S3:*** *UV-Visible absorption spectra (background subtracted) of the BP38E0.3 mixture in the pristine and UV irradiated states.*

In all the mixtures, two absorption peaks are obtained at ~ 380 nm and ~450 nm in the pristine state, which can be attributed to the π-π\* and n-π\* transitions respectively, as discussed above. A representative case of BP38E0.3 mixture is shown in Figure S3, where the peaks corresponding to the π-π\* and n-π\* transitions are denoted as P1 and P2 respectively. Upon UV irradiation, the absorbance of the peak at ~ 380 nm decreases (see Figure S3), which clearly indicates the occurrence of *trans-* to *cis-* isomerization. A blue shift of ~ 20 nm observed in the n-π\* peak could be due to the increased binding affinity [Ref.S3] of the *cis-* isomer of EPH with the host medium.

The trans-cis conversion efficiency was calculated based on the UV-Visible absorption peak at ~380 nm. Here it has to be emphasized that the selective reflection peak wavelength obtained closest to the ~ 380 nm absorption peak is ~ 440 nm with a FWHM of ~ 20 nm and onset wavelength of ~ 430 nm. Hence the absorption peak corresponding to the π-π\* transition does not coincide with any of the selective reflection peak wavelengths obtained.

The photo-isomerization quantum yield is calculated according to the relationship:

η = (IP1(NO UV) - IP1(UV)) / (IP1(NO UV)  \*100

where, IP1(NO UV)  and IP1(UV)) indicate the absorbance (of the π-π\* peak) in the pristine and UV irradiated states respectively.

***Chiral dopant to trans-EPH ratio***

In the pristine state, EPH is assumed to contain 100% *trans*- isomers. Therefore, the wt% of *trans-*EPH is taken as wt% of EPH\*1. In the UV irradiated state, majority of the *trans-* isomers are converted to *cis-*form (as given by the conversion efficiency, η). Hence, the wt% of the remaining *trans-* isomers is obtained as: wt% of EPH\*(100- η)/100.

Thus, the chiral dopant to *trans-* EPH ratio is calculated as:

1. For BP38E0.3, in pristine state:

$\frac{wt\% of S811}{wt\% of EPH\*1}= \frac{38}{0.3}= $127

In the UV irradiated state:

$\frac{wt\% of S811}{wt\% of EPH\*(100-η)/100 }$ $= \frac{38}{0.3\*0.48}=$ 264 (as η = 52%)

1. Similarly for BP25E0.3, in pristine state:

$\frac{wt\% of S811}{wt\% of EPH\*1}= \frac{25}{0.3}= $83

In the UV irradiated state,

$\frac{wt\% of S811}{wt\% of EPH\*(100-η)/100 }$ $= \frac{25}{0.3\*0.56}=$ 149 (as η = 44%)

The ratios thus obtained are given in the main manuscript section 3.1.

**S5. Selective reflection wavelength tunability with electric and optical fields in BP38E0.5 and BP38E1**

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***Figure S4****: Electric and optical field dependence of the selective reflection wavelength for the BP38E0.5 sample.*

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***Figure S5****: Electric and optical field dependence of the selective reflection wavelength for the BP38E1 sample.*

**References**

Ref.S1. P. P. Crooker in *Chirality of liquid crystals - Partially Ordered Systems,* Ed: H. S. Kitzerow, C. Bahr, Springer, New York, NY, Ch. 7, pp: 186-222.

Ref.S2. G. S. Hartley,The cis-form of azobenzene, *Nature,* 1937, **140**, 281.

Ref.S3. H. Huang, A. Juan, N. Katsonis and J. Huskens, Competitive inclusion of molecular photo-switches in host cavities, *Tetrahedron,* 2017, **73,** 4913.