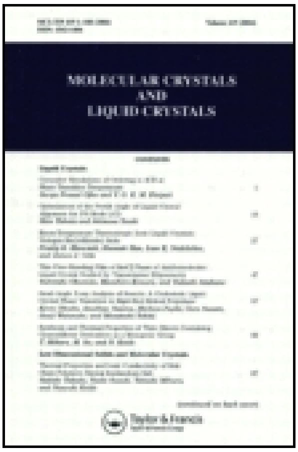

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Temperature-Dependent Behaviours of Blue Phase I Observed for a Bent-Core Molecular System

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Temperature-Dependent Behaviours of Blue Phase I Observed for a Bent-Core Molecular System

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Temperature-dependent behaviours, such as the Bragg reflection band and the EO performance, of the liquid-crystalline BP I observed for a nematogenic achiral bent-core molecule doped with a small amount of chiral additive was investigated. Our experimental results indicate that the physical behaviours of our sample were highly sensitive to temperature changes.

Keywords liquid crystal; blue phase; bent-core molecule; chiral dopant; temperature; Kerr effect

Introduction

Blue phases (BPs) have been attracting much attention from researchers across a wide range of applied fields [1]. This is because BPs can be exploited for their potential applications in the fields of optoelectronics and photonics [2–4]. Generally, BPs appear over a narrow temperature range (approximately 1°C) between the chiral nematic phase (N*), which has a relatively short helical pitch, and the isotropic phase [1,2]. BPs are considered to consist of a double-twist-cylinder (DTC) structure and are classified into three categories depending on the assembly structure of the DTC: BP I, BP II, and BP III, listed in the order of increasing temperature [1, 5–7]. BP I and BP II show cubic symmetry and Bragg reflections in the range of visible light.

Recently, we investigated BPs of a nematogenic achiral bent-core molecule doped with a small amount of chiral additive [8]. When a bent-core molecule with molecular biaxiality was used as the host material, the observed temperature range increased to more than 15°C, which is substantially larger than the temperature range of uniaxial rod-like mesogen systems blended with chiral additives. This phenomenon is thought to originate from the coupling between the biaxiality and chirality, which results in the stabilisation of the DTC structure. In this work, we report the observation of temperature-dependent behaviours

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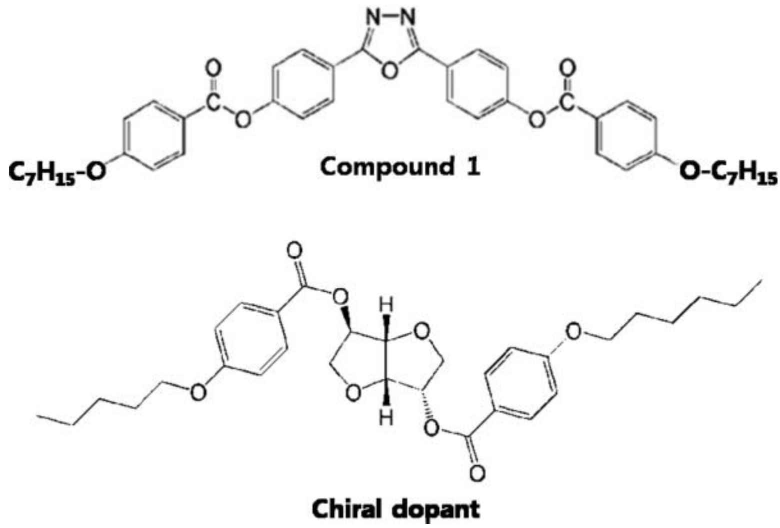

Figure 1. Chemical structures of the host NLC and chiral dopant used in this work.

such as Bragg reflection and the electro-optical (EO) performance of liquid-crystalline BP (especially stable BP I) in the bent-core molecular system.

Experimental Procedures

The host liquid-crystalline material used in this study was a bent-core mesogen (compound 1) in the nematic (N) phase [8–10]. In order to introduce chirality into the host nematic liquid crystal (NLC), a small amount (10 wt%) of a chiral dopant with high twisting power was added. The chemical structures of the host NLC and chiral dopant are shown in Fig. 1. The BP textures of the LC material were observed under a polarised microscope with a hot stage. The Bragg reflection band in BPs was investigated using a visible light spectrometer.

To measure the EO performance, we prepared sandwiched cells with comb-type interdigitated electrodes according to the method described in Refs [11–13]. A He–Ne laser (633 nm with a power of 5 mW) was used as a probe light. The fabricated cells were placed perpendicular to incident light. We confirmed that maximum transmitted light was obtained when the field direction was at an angle of ±45° with respect to the polariser directions. The transmitted light intensity (I_{out}) through the cell placed between the crossed polarisers is given by

$$I_{out} = I_{in} \sin^2(\pi \Delta n_{induced} d/\lambda), \quad (1)$$

where I_{in} is the input intensity, $\Delta n_{induced}$ is the induced birefringence, and d is the cell gap.

Results and Discussion

Figure 2 shows typical BP textures of our samples upon cooling from the isotropic phase; cooling was carried out at 1°C/min. The isotropic liquid had a foggy phase and fluidity, indicating that the phase was BP III. On further cooling, BP III changed to a BP containing platelets, indicating that the phase was BP I. The observed temperature range of BP I was approximately 15°C (from 187°C to 172°C during the cooling process). It can be

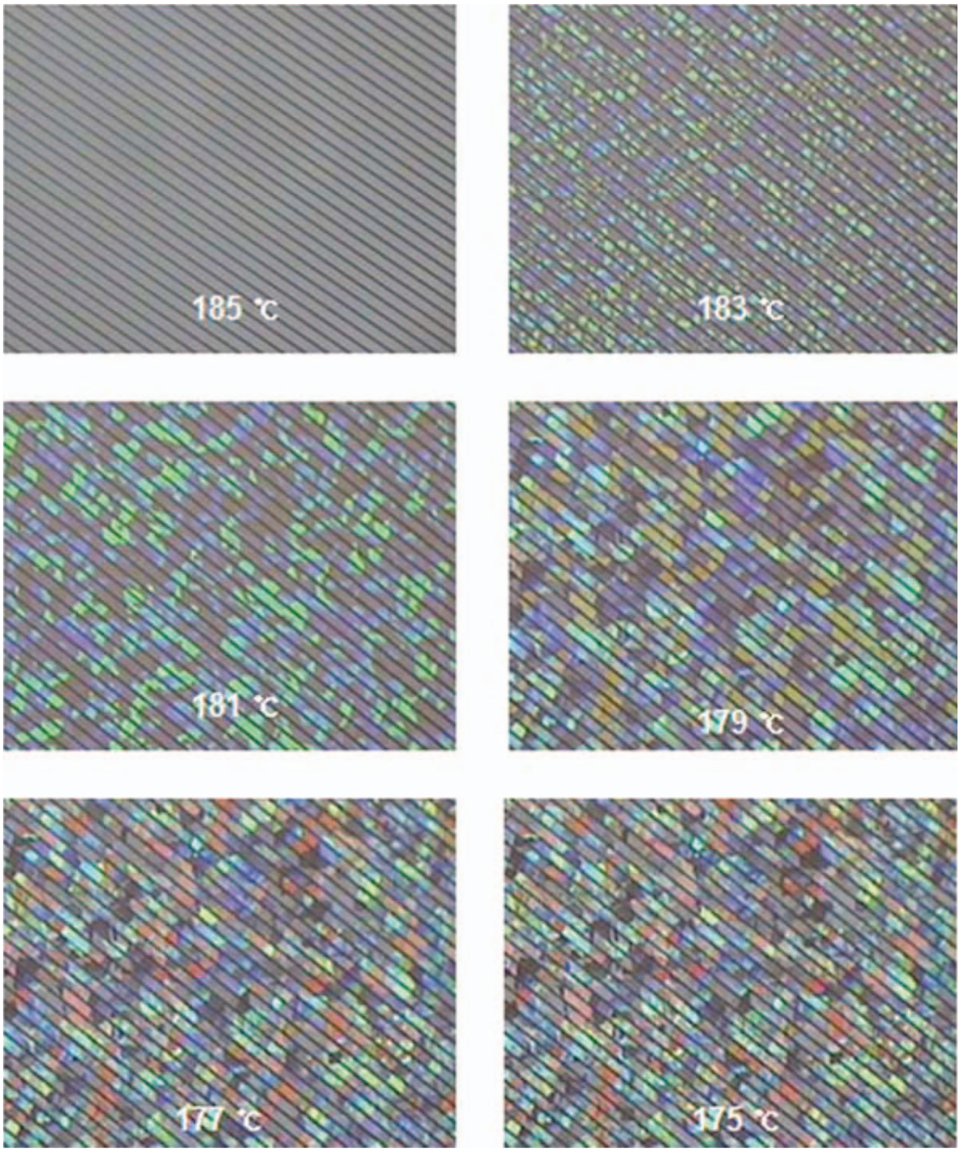

Figure 2. Typical BP textures upon cooling from the isotropic phase at several temperatures.

seen from Fig. 2 that the observed sizes and colours of the platelets changed with temperature. The BP with a blue and green colour changed to that with a yellow and orange colour.

Next, Bragg reflection was detected as a function of temperature. For this purpose, we focused on a reflection peak corresponding to Bragg diffraction from the (110) plane. As shown in Fig. 3, the peaks shifted from a short wavelength to a long wavelength. This trend corresponded to the above-mentioned phase texture behaviours. The observed temperature

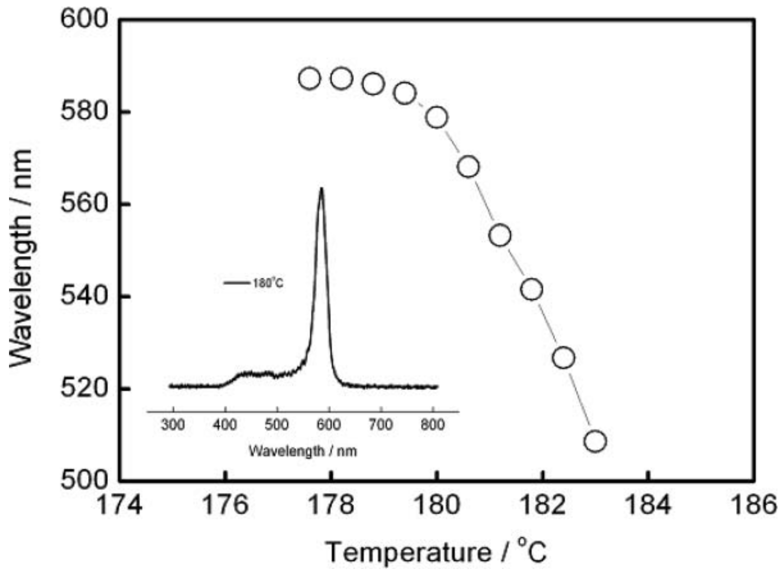

Figure 3. Detected Bragg reflection band at several temperatures. Typical reflection peak at 180°C is also shown in the inset.

dependence of the Bragg reflection was because of the change in the lattice constant of BP I with temperature.

Finally, the temperature dependence of the EO performance was evaluated. A nonlinear optic effect can be induced in BPs by the application of an electric field, which is called the EO Kerr effect. The Kerr effect can be expressed by

$$\Delta n_{\mathrm{induced}} = \lambda \cdot K \cdot E^2, \qquad (2)$$

where λ is the wavelength of the probe light, E is the applied electric field, and K is the Kerr constant [11–13]. The value of the Kerr constant was determined from the plots of $\Delta n_{\mathrm{induced}}$ as a function of the square of the applied electric field. Figure 4 shows plots of $\Delta n_{\mathrm{induced}}$ for our sample, which was measured at several temperatures as a function of the square of the electric field. As shown in Fig. 4, it is clear that $\Delta n_{\mathrm{induced}}$ is approximately proportional to the square of the electric field, and the slope indicates the Kerr constant. As shown in Fig. 4, a relatively steep temperature dependence of the Kerr effect was observed. The temperature dependence of the Kerr constant for our sample is recorded in Table 1.

Table 1. Evaluated Kerr constant at several temperatures

Temperature/°C	183	181	177	175
Kerr constant/$\times 10^{-9}$ mV^{-2}	0.17	0.18	0.22	0.28

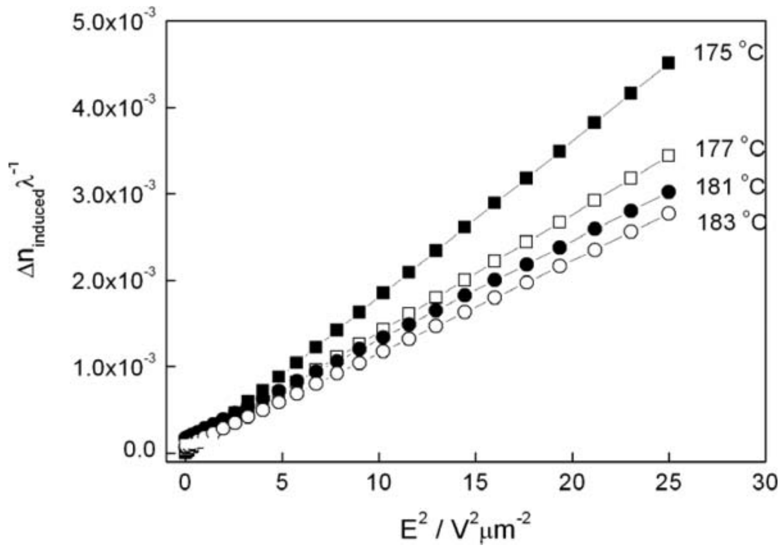

Figure 4. Plots of $\Delta n_{\text{induced}}$ for our sample measured at several temperatures as a function of the square of the electric field.

Conclusions

We investigated temperature-dependent behaviours, such as the Bragg reflection band and the EO performance, of the liquid-crystalline BP I observed for a nematogenic achiral bent-core molecule doped with a small amount of chiral additive. Our experimental results indicate that the physical behaviours of our sample were highly sensitive to temperature changes.

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References

[1] Hur, S.-T., Gim, M.-J., Yoo, H.-J., Choi, S.-W., and Takezoe, H. Soft Matter, (2011), DOI: 10.1039/clsm06046e.
[2] Kikuchi, H., Yokota, M., Hisakado, Y. Yang, H., and Kajikawa, T. *Nat. Mater.*, **1**, 64 (2002).
[3] Hisakado, Y., Kikuchi, H., Nagamura, T., and Kajiyama, T. *Adv. Mater.* **17**, 96 (2005).
[4] Yokoyama, S., Mashiko, S., Kikuchi, H., Uchida, K., and Nagamura, T. *Adv. Mater.* **18**, 48 (2006).
[5] Crooker, P. P., in *Chirality in Liquid Crystals* (Eds: H.-S. Kitzerow and C. Bahr), Springer, New York 200l, pp. 186–222.
[6] Wright, D. C. and Mermin, N. D. *Rev. Mod. Phys.* **61**, 385 (1989).
[7] Kitzerow, H.-S. and Crooker, P. P. *Phys. Rev. Lett.*, **67**, 2151 (1991).
[8] Lee, M., Hur, S.-T., Higuchi, H., Song, K., Choi, S.-W., and Kikuch, H. *J. Mater. Chem.*, **20**, 5813 (2010).

[9] Madsen, L. A., Dingemans, T. J., Nakata, M., and Samulski, E.T. *Phys. Rev. Lett.*, **92**, 145505 (2004).
[10] Acharya, B. R., Primak, A., and Kumar, S. *Phys. Rev. Lett.*, **92**, 145506 (2004).
[11] Choi, S.-W., Yamamoto, S., Haseba, Y., Higuchi, H., and Kikuchi, H. *Appl. Phys. Lett.*, **92**, 043119 (2008).
[12] Choi, S.-W., Yamamoto, S., Iwata, T., and Kikuchi, H.,, *J. Phys. D: Appl. Phys.*, **42**, 112002 (2009).
[13] Choi, S.-W., Yamamoto, S., Haseba, Y., and Kikuchi, H. *Opt. Mater.*, **32**, 190 (2009).