Polarized microscopic FT-IR for molecular orientation of chiral nematic liquid crystal

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Blue phase (BP) exist over a very small range in temperature at the boundary of chiral nematic and isotropic phases of chiral nematic liquid crystal (N^*LC). The BP has been subdivided into three phases, *i.e.*, BP I, BP II and BP III, according to the phase transition by temperature change[1]. Study on molecular orientation change of each phase consequent upon conformational changes by phase transition is important to reveal the mechanism of stability of BPs and developing of new generation LC display devices as well. In this study, the polarized microscopic FT-IR spectroscopy has been applied for study on parallel and vertical molecular orientation change of N^*LC including BPs by phase transition.

The N^*LC sample was prepared by mixing with NLCs (5CB:6CB:5OCB:7OCB = 3:2:4:1) and $ISO(6OBA)_2$ of chiral dopant. The samples with concentrations of 5wt%, 7wt%, and 9wt% for dopant were sandwiched into two CaF_2 substrates coated by thin film of polyvinyl alcohol (PVA) or dimethyl octylchlorosilane. The 14 μm-thickness polystyrene films were used for spacer in the cell. The polarized infrared spectra measurements of N^*LC molecules were carried out by FT-IR spectrometer (Perkin Elmer, Spectrum One) equipped with microscope unit. The temperature was controlled in the range between 35.0 and 42.0 ºC by the hot-stage (Mettler, FP82HT).

Figure 1 shows polarized microscopic observation of each phase of N^*LC in the 7wt% of chiral dopant cell. The following phase transition sequences are observed: BP III at 39.8 ºC and isotropic phase at 41.0 ºC on heating; BP III at 40.8 ºC, BP II at 40.2 ºC, BP I at 39.8 ºC and N^* phase at 38.0 ºC on cooling. Meanwhile, the 5wt% and 9wt% cells show no BPs and BP III only on cooling, respectively.

Figure 2 illustrates the band intensity ratio of CN and CH_2 stretching modes (CN/CH_2) at non-polarized IR measurements on heating and cooling process. The CN/CH_2 ratio of N^*LC in the 7wt% cell is decreased by phase transition from N^* phase to BP III on heating, while it is also decreased by phase transition from BP I to N^* phases on cooling process. These results suggest that the molecular orientation of NLC in N^* phase is changed to considerably vertical with respect to the substrate on cooling process. While the CN/CH_2 ratios of N^*LC for the 5wt% and 9wt% cells are decreased by phase transition from N^* to isotropic phases on heating, their ratios are almost same in isotropic and N^* phases on cooling process.

The band intensity ratio of CN stretching modes of polarized IR measurements ($A_{//}/A_{\perp}$) for each cell is shown in Figure 3. The ratio of is larger at 130 degree with respect to the long axis of substrate for both in parallel and vertical cells of the N^* phase on cooling process, indicating that the helical axis of N^*LC on cooling process is incline with respect to the parallel direction whereas that had been vertical to the substrate before heating.

In conclusion, it is suggested that the lattice of BP I affects the molecular orientation change of N^*LC on cooling process.

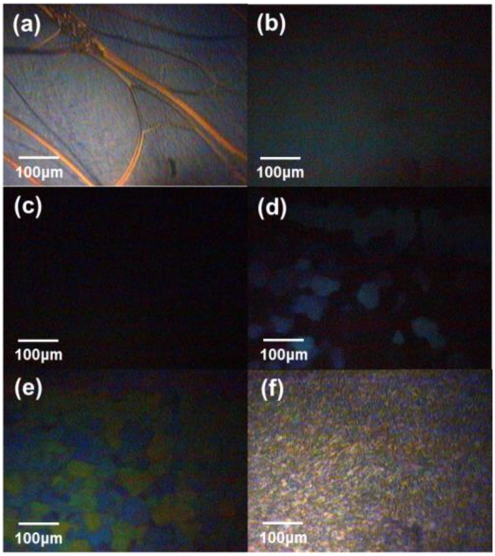

Figure 1. Micrographs of N^*LC in (a) N^* phase at 39.0°C, (b) BPIII at 39.8°C, (c) Iso at 41.0°C on heating, and (d) BPII at 40.2°C, (e) BPI at 39.8°C and (f) N^* phase at 38.0°C on cooling.

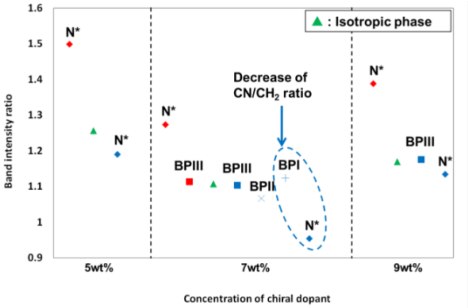

Figure 2. The changes of band intensity ratio of CN/CH_2 for each cell by phase transitions on heating and cooling.

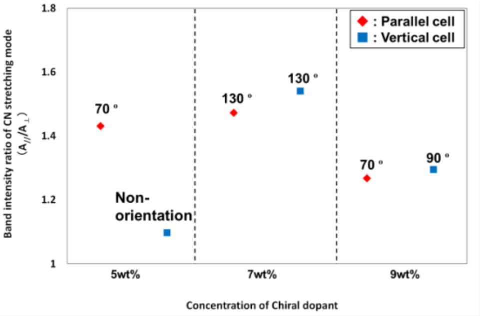

Figure 3. Band intensity ratio of CN stretching mode ($A_{//}/A_{\perp}$).

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[1] Chen W.R. and Hwang J.C. (2004), *Liquid Crystals*, 31 (11), 1539-1546.