Orientation Dependence of Photoluminescence Based on the 4-n-pentyl-4'-cyanobiphenyl Liquid Crystal

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Abstract: This study investigates the photoluminescence spectra of nematic liquid crystals (NLCs) 4-n-pentyl-4'-cyanobiphenyl (5CB). The photoluminescence intensities of rubbed or unrubbed sample cells gradually decreases when the LC director reorients from 0° to 90° with respect to the polarized laser beam.
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1. Introduction

The polarized photoluminescence (PL) of photopolymerizable LCs and polymer film has gained considerable interest because of its applications in displays [1–8]. Linearly polarized luminescence significantly improves the brightness and viewing angles of liquid crystal displays (LCDs). The polarization of emitted light has been studied by chromophore-doped anisotropic polymer films [3–6] or solid films of nematic and chiral-nematic polys [9]. A few reports have discussed nematic liquid crystals (NLCs) as sources of PL; the crystals potentially increase the brightness of LCDs.

This study investigates the PL intensities of NLCs in rubbed or unrubbed sample cells. The dependence of the PL intensity on the orientation of LC director with respect to the polarized beam is also studied. Results show that the PL intensities gradually decrease when the LC director is reoriented from 0° (parallel to the beam) to 90° (perpendicular to the beam) [10].

2. Experimental

The 4-N-pentyl-4'-cyanobiphenyl (5CB) LCs were used as experimental materials, and the chemical structure of which is shown in Fig. 1(a). The nematic state of 5CB occurs from 18 °C to 35 °C. The LCs were capillarily injected into the sample cell assembled from pairs of glass plates and spaced at about 5.4 μm. The homogeneous planar alignment of NLCs was achieved by unidirectionally rubbing a thin layer of polyimide on the surface of the front glass substrate.

The NLCs were planarly aligned, and the LC director was initially parallel to the x-axis. The alignment of LCs was confirmed by the polarized absorption spectrum (data not shown). The absorption intensity of the parallel polarized light was larger than that of the perpendicular polarized light

respective to the director axis of the LCs. A 325 mm He–Cd laser was used as the excitation source, with an excitation power of approximately 1 mW. The polarized excitation source and the director of the sample cell are parallel to the x-axis, and the sample cell was gradually rotated to the y-axis. PL spectra were measured with a fluorescence spectrophotometer; all of the spectra were reproducible. Fig. 1(b) shows the experimental setup.
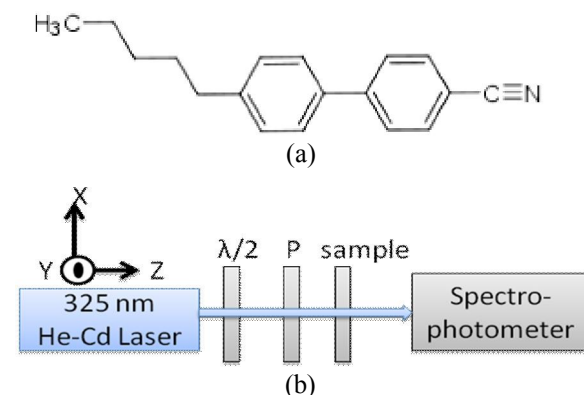

Fig 1. (a) Chemical structure of 5CB; (b) Experimental setup. Abbreviations: λ/2, half-wave plate; P, polarizer.

3. Results and Discussions

Figure 2 illustrates the luminescence signal from the sample cell and the PL spectrum upon laser excitation. The polarized excitation source and the director of the sample cell were parallel to the x-axis. The luminescence spectrum from the sample cell ranges from 350 nm to 500 nm. The position of the maximum intensity is located at ~391 nm.

PL intensities of the rubbed and unrubbed sample cells are shown in Fig. 3. The PL intensity of the rubbed sample cell is larger than that of the unrubbed sample cell. The absorption efficiency of the NLCs in the rubbed sample cell is larger than that

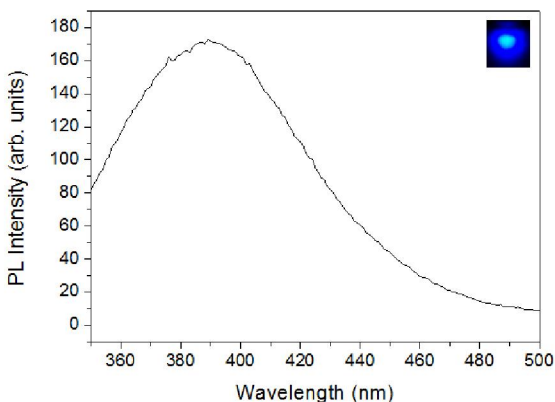of the unrubbed sample cell, which results in PL intensity.

Fig 2. Luminescence signals from the sample cell and the PL spectrum upon the excitation of 325 nm He–Cd laser.
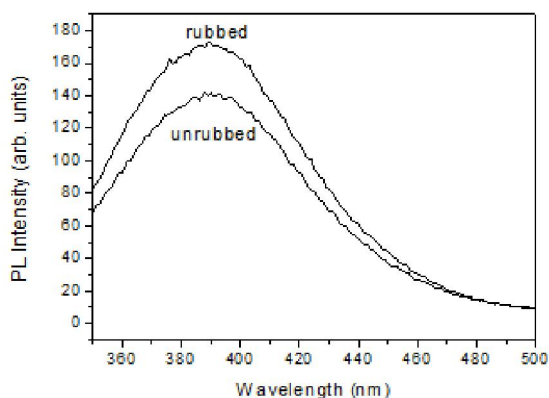

Fig 3. PL intensities of rubbed and unrubbed sample cells.

Figure 4 shows the peak intensities of the PL spectra for various orientations of the LC director with respect to the polarized excitation beam. The orientation of the LC director was adjusted by a rotator from 0° (x-axis) to 90° (y-axis). The polarized excitation source remained parallel to the x-axis. The maximum and minimum peak intensities are found at 0° and 90°, respectively. For the LC director positioned parallel to the x-axis, the NLC absorption is strongest, and the ratio of absorption ($A_{0°}/A_{90°}$) at 325 nm is about 3.1. The PL ratio ($I_{0°}/I_{90°}$) of the LCs is about 3.0. $A_{0°}/A_{90°}$ and $I_{0°}/I_{90°}$ exhibit very close values, which are attributed to the absorption of NLCs that results in changes in the PL intensity. Strongest LC absorption occurs at 0°, and yields a maximum PL intensity. The modulation of the absorption of LCs by rotating the director influences the PL intensity; hence, LC absorption decreases with the latter. The PL intensity gradually decreases with

increasing angle between the polarized excitation beam and the LC director. The weakest LC absorption is at 90°, which results in a minimum PL intensity.
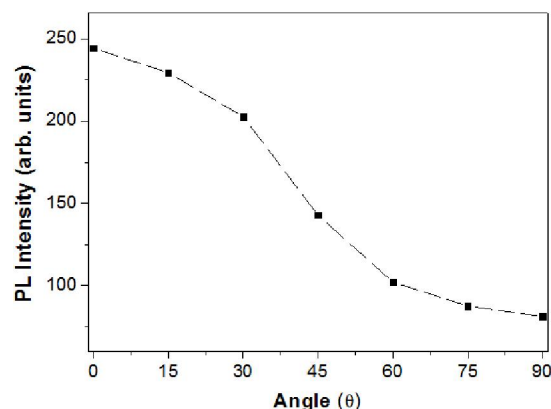

Fig. 4 Peak intensity of PL spectra for different orientations of the LC director with respect to the polarization of excitation beam

4. Conclusion

Overall, the PL intensity is influenced by the state of the sample cell (rubbed or unrubbed). The peak intensity of the PL spectra changes with the orientation of the LC director with respect to the polarized excitation beam. Maximum and minimum peak intensities are found at 0° and 90°, respectively. The absorption of NLCs is strongest at 0°, and yields a maximum intensity; whereas, the weakest NLC absorption occurs at 90°, which results in a minimum PL intensity.

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