Light Induced Structural Transition in B_7 phase of Bent-shaped Liquid Crystals containing Azo dye

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Abstract

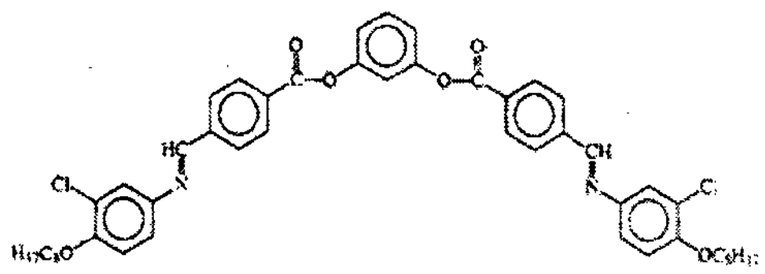
The influence of isomeric state of doped azo dye on the B_7 phase of bent-shaped liquid crystal (LC) is studied. It was found that modulating the isomeric trans-cis state of azo dye can change the molecular arrangement of the bent-shaped LCs. To identify these phenomena the observations of microscopic texture, electro-optic response, second harmonic wave generation (SHG) and switching current were carried out..

1. Introduction

Since the discovery of ferroelectricity from achiral bent-shaped LC [1], extensive investigations have been mainly done on B_2 phase of these material [2],[3]. But the B_7 phase of bent-shaped LC has the most complicated textures and the structure has not been clearly known yet [4], and the alignment of bent-shaped LC is known to be quite difficult. In this paper, with the material of PBCOB (1,3-phenylene bis [4-(3-chloro-4-n- octyloxy - phenyl imino methyl) benzoate]) of B_7 phase, the structural identification and the possibility of LC structure transformation in the the azo dye doped B_7 phase induced by the light irradiation are investigated for the first time.

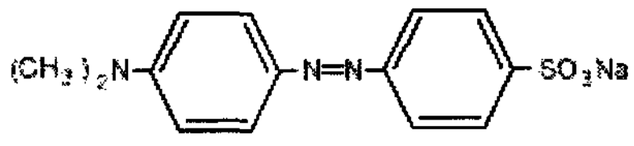
2. Experiments

The molecular structure of the materials used in this experiments, PBCOB and that of methyl orange is shown in Figure 1 (a).



PBCOB

(a)



(b)

Figure 1. Molecular structure of (a) PBCOB and (b) methyl orange.

It was observed that the cell of pure PBCOB of B_7 phase shows two distinctively different domains in the cooling process. One kind of domain is bright and the other kind of domain is dark under the polarizing microscope. To identify the arrangement of LC molecules in these domains, we carried out

the observation of microscopic texture and electro-optic response and measured the refractive indices and second harmonic wave generation (SHG) intensity for both domains.

After determining the structure of the pure LC in the B_7 phase arrangement from these results, we made a cell containing PBCOB doped with 5 wt.% azo dye. The azo dye used in this experiments was the methyl orange of the molecular structure shown in figure 1 (b). It is observed that in the scope of this experiment the pure PBCOB and azo dye doped PBCOB have similar textures and properties with each other.

For the cell doped with azo dye we illuminated Ar laser (Innova 305,Coherent Co.) beam with linear or circular polarization to modulate the trans-cis state of the azo dye. The intensity of the irradiated laser beam is 890 mW. Before, during and after illumination of laser beam, the experiments of switching current measurements and texture observation by polarizing microscope were carried out simultaneously. The analysis on these results was carried out.

3. Results

The bright domains show distinctive electro optic switching behaviors such as the change of brightness of each domain and the rotation of extinction brush. On the contrary, the grey domains do not show any electro optic switching behaviors at all.

The birefringence values measured via polarizing microscope are 0.057 for bright domains, and 0.0085 for the dark domains.

Next, the results of SHG measurement clearly shows that the bright domain has the SHG signals even in the absence of biasing electric fields shown in Figure 2 at normal incidence. On the contrary, the grey domain does not show any SHG signals even in the application of moderate electric fields in any possible combination of light polarization.

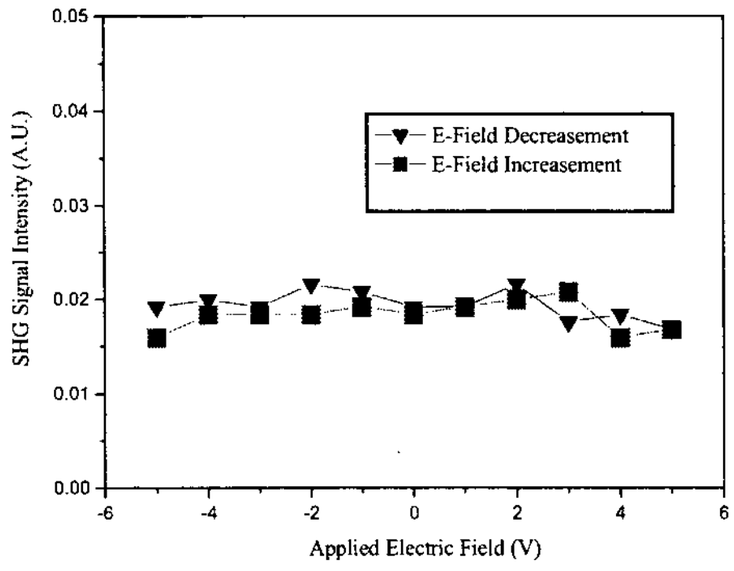
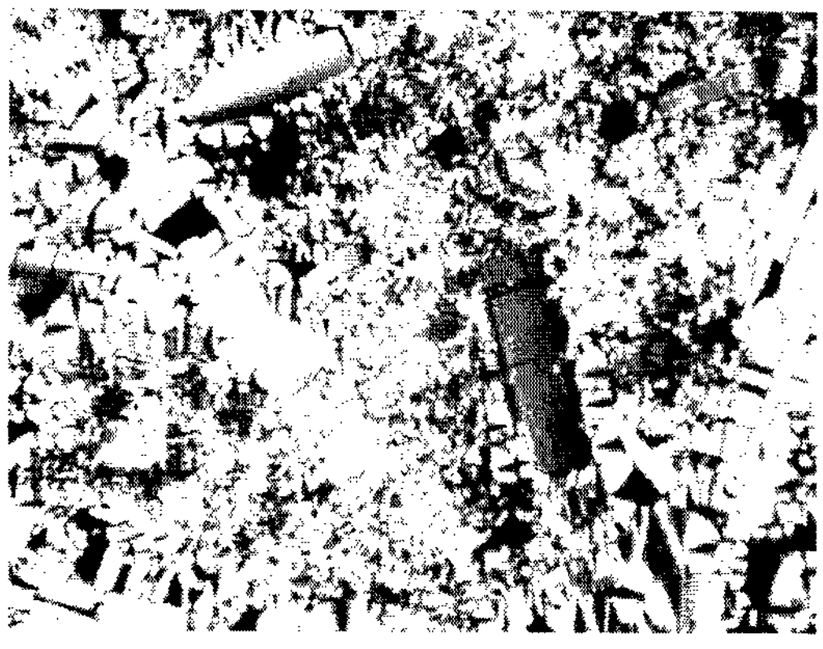


Figure 2. Second harmonic wave intensity vs the bias electric fields in the bright domains under p-p polarization combination.

The illumination of the polarized Ar ion laser beam onto this state results in the remarkable transformation of dark domains into bright domains as shown in Figure 3.

(a) before illumination of light



(b) after illumination of light

Figure 3. Textural transition of dark domains into bright domains by the irradiation of circularly polarized light on the LC doped with azo dye.

The switching current measurement carried out simultaneously with light illumination process shows that the switching current value is increased during the illumination of light and relaxed a little bit after illumination as described in Figure 4.

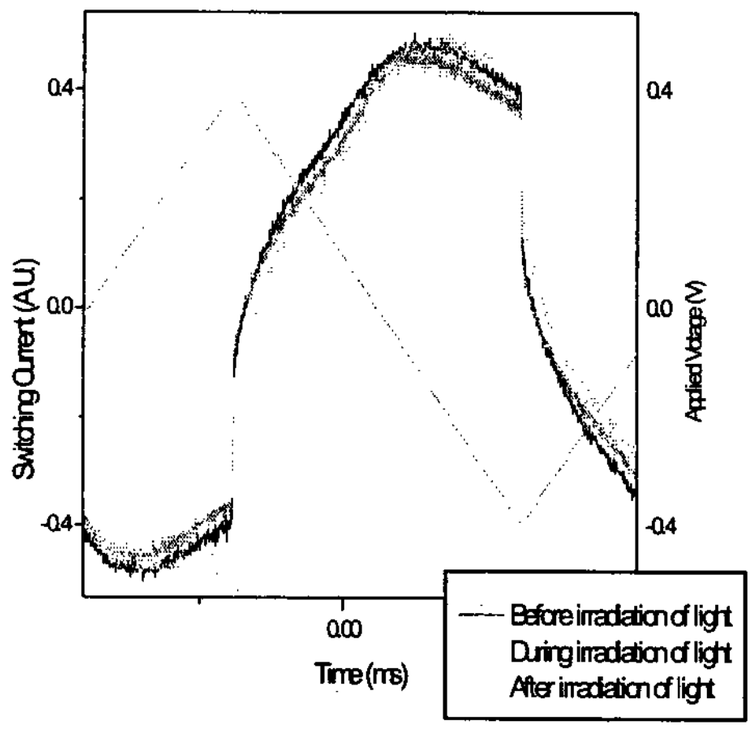


Figure 4. Switching current variation before, during and after illumination of laser light.

4. Discussion

The results of the experiments carried out to identify the bright domains and dark domains clearly reveal that the bright domains have planar smectic synclinic ferroelectric (SmC_sP_F) layer alignment whereas the grey domains have homeotropic layer alignment of the same SmC_sP_F configuration[4].

If polarized light is irradiated into this dark homeotropic region, the azo molecules would be excited into bent-shaped cis state, and in this process, the bent-shaped cis dye molecules would expand the spacing of LC molecules within a layer. This process inevitably make the LCs to be move more freely in the cell, and then the whole homeotropic layer assemblies are to be transformed into more stable planar configurations. It can be postulated that this process resulted in the textural change from dark domains into bright domains as shown in Figure 3.

But as shown in Figure 3, for the bright region of planar LC alignment the molecules are arranged parallel to the substrates with layers perpendicular to the substrates, on the contrary to the homeotropic alignments. In this case when the linearly or circularly polarized light is irradiated, the expanding of intra layer spacing caused from the bending of azo molecules would make the LC molecules to move, but it can not cause the change of assembly of LC molecules of planar alignment. So as shown in Figure 3, the planar bright textures remain the same texture as the original bright state upon irradiation of light.

From the results of switching current measurements as shown in Figure 4 it can be seen that the switching current is increased during the irradiation of light and decreased again after turning off the light. This may indicate that among the current components consisting the total current across the cell, the capacitive current component and ionic current are increased by the change of the cell parameters such as the dielectric constants, which is possible in the process of transformation of LC arrangemnet from homeotropic configuration into planar one as well as the transformation of azodye from trans state into cis state.

5. Conclusion

Two kinds of domains are found to coexist in B_7 phase of bent-shaped LCs, various experiments to identify the structure of each domain were carried out. The results indicate that the bright domains have smectic synclinic and ferroelectric, SmC_SP_F configuration with planar director arrangement, while the dark domains have the same structure with homeotropic arrangement. In addition for the first time it is discovered that the irradiation of light on the B_7 phase doped with azo dye can cause the transformation of LC in B_7 phase from homeotropic LC arrangement into planar one, and the possible mechanism of this transformation was suggested. These results highlights the structural identification of the B_7 phase of bent shaped LC and opens the possibility of the light mediated control of layer transition and alignment in bent- shaped LC.

6. Acknowledgement

7. References

[1] Niori, T. et al., *J. Mater. Chem.*, **6**,1231(1996)

[2] Nair, G.G. et al., *J. Appl. Phys.*, **90**, 48(2001)

[3] Link, D.R. et al., *Science*, **278**, 1924 (1997)

[4] Jakli, A. et al., *Phys. Rev. Lett.*, **86**, 5715