Effect of Concentration of the Guest Dichroic Dye in Guest-Host Liquid Crystal Panel for Viewing Angle Controller of Display

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ABSTRACT

In this paper, we experimentally demonstrated the viewing angle control using the guest-host (GH) liquid crystal (LC) panel and measured its viewing angle property, extinction coefficients corresponding to concentration of the guest dichroic dye in GH LC panel.

1 INTRODUCTION

Recently, viewing angle modulation of display has attracted attention for protection of the privacy and the security. There are many approaches to obtain the viewing angle switching (VAS) for display [1-5]. The one of the methods is guest-host (GH) liquid crystal (LC) panel using mixture of host LC and guest dichroic dye (DD) [1, 5-6]. The performance of the VSA of display is related to the transmittance and absorption. Chen *et al*. proposed schematically VAS of display panel design and showed the simulation result of the VAS using GH panel proposed [1].

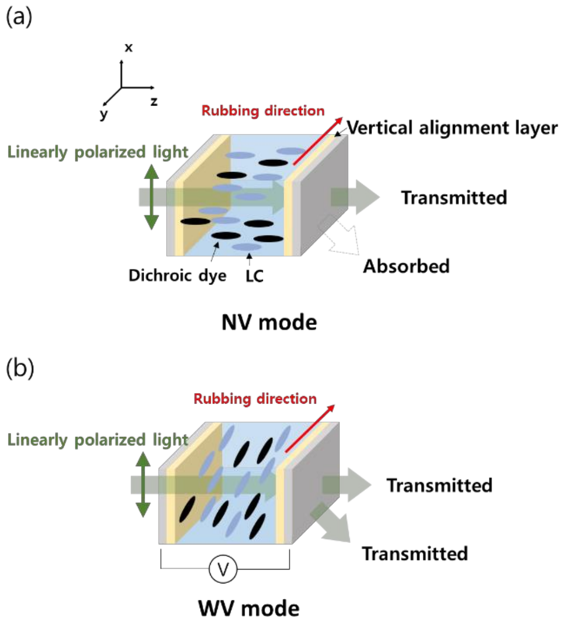
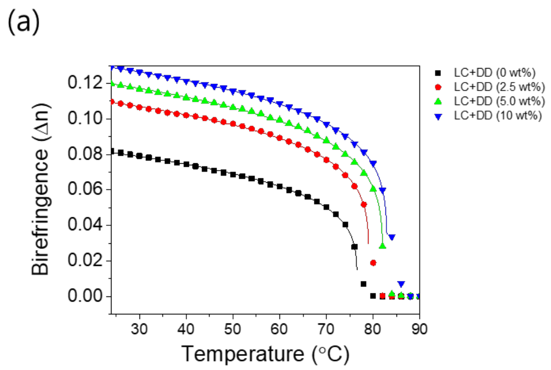


Fig. 1 Schematic illusion of operation principle of the (a) NV and (b) WV mode.

In this paper, we experimentally confirmed the VSA of display using GH panel and investigated the dependence of VAS property on concentration of DD in the LC mixture. For experimental convenience, we modified structure of previous literature and fabricated the GH cell using mixture of the guest DD and the host LC. The GH mixture, which has a negative dielectric anisotropy $\Delta\varepsilon$, was vertically aligned at non-applying voltages. As shown in Fig. 1(a), at normally view, the light is transmitted with no absorption because the DD molecules are perpendicular to the polarization of incident light. At obliquely view, the incident light is absorbed by increased absorption of DD molecules, showing the NV property [Fig. 1(a)]. When applying voltage to the cell, the GH molecules were planar aligned with their long molecular axis perpendicular to the polarization direction of the incident light. There is no absorption at normal and oblique view, showing the WV property [Fig. 1(b)]. To confirm the dependence of VAS property on concentration of DD, we measured the order parameter *S*, extinction coefficients, transmittance (TR) of GH cell.

2 EXPERIMENT

For the experiment of fabricating the VAS panel, we uesd a commercial DD Irgaphor Black X12 (BASF) and LC ZKC7000 (JNC) at weight ratio of 0, 2.5, 5.0, and 10.0 wt%.



(b)

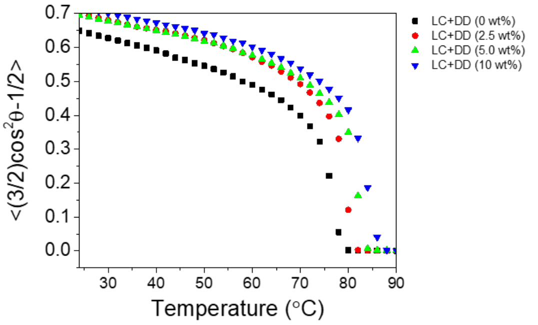


Fig. 2 (a)The birefringence Δn, (b) order parameter with various concentration of DD vs. temperature *T*.

First, we checked that the DD molecules are well diluted and oriented with the LC molecules. We fabricated the cell coated with planar aligned layer to measure the spatially averaged birefringence Δn and order parameter *S*=<3/2cos^{2}θ-1/2>, where θ is the local angular deviation of the molecular orientation. Order parameter was measured by fitting Δn with the empirical equation $\Delta n = \delta n(1 - T/T*)^{\beta}$, where *T* is the absolute temperature, and T^*, δn and β are fitting parameter [7-8]. Fig. 2(a) shows the birefringence Δn vs. temperature *T* with various weight ratio of DD. The birefringence, transition temperature of nematic phase to isotropic phase (T_{NI}) slightly increased with a greater concentration of DD. It means that concentration of DD can affect to LC molecules orientation. We calculated the order parameter *S* of the GH mixtures by fig. 2(a) [Fig. 2(b)]. Order parameters of the 0, 2.5, 5.0, and 10 wt% of DD correspond to 0.65, 0.70, 0.70, and 0.72 respectively. The order parameter *S* was increased with a greater concentration of the DD molecules. It was experimentally confirmed that DD molecules are well diluted and oriented in the LC molecules with increased *S*.

3 RESULTS & DISCUSSION

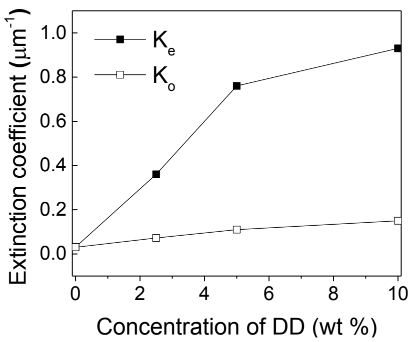
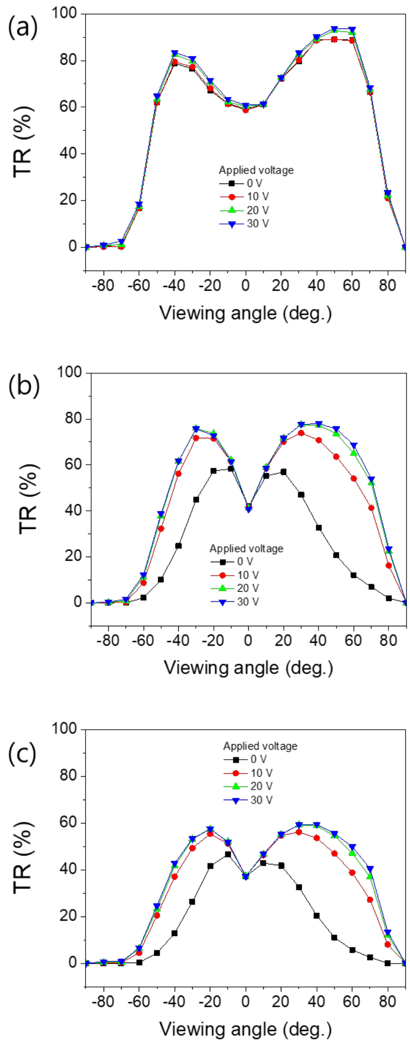


Fig. 3 Measured results of extinction coefficient vs. concentration of DD.

To confirm the effect of concentration of DD in GH cell for switching viewing angle of display, we experimentally measured the extinction coefficients of various GH cell [Fig. 3]. In general, the electric field of light when passing the medium is expressed as $E = E_0 exp(-k"z) expj(wt - k'z)$, where k' is the wave vector, $k"$ is the extinction coefficients [9]. In addition, the transmittance (TR) can be expressed as $TR = T_0\, exp(-2k''z)$, where T_0 is the TR of the input beam [9]. We fabricated the planar aligned cell with various concentration 0, 2.5, 5.0, and 10 w% of DD, and measured the TR spectra with various concentration of DD. The extinction coefficients along the slow axis of the mixture k_e'', along the fast axis of the mixture k_o'' are calculated from the TR spectra data when the polarization of input beam is parallel, perpendicular to rubbing direction of GH cell, respectively.

As shown in Fig.3, The k_e'' of the 0, 2.5, 5.0, and 10 w% DD-mixed LC was 0.031, 0.36, 0.76, and 0.93 μm^{-1}, respectively. The k_o'' of the 0, 2.5, 5.0, and 10 w% DD-mixed LC was 0.030, 0.072, 0.11, and 0.15 μm^{-1}, respectively.



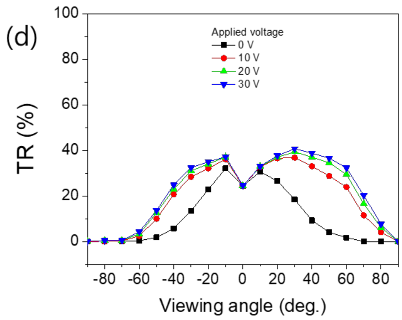


Fig. 4 Experimental results of the TR vs. horizontal viewing angle. The concentration of the DD in GH cell is (a) 0, (b) 2.5, (c) 5.0, and (d) 10 wt%.

We fabricated the vertically aligned GH cell for VSA of display. We measured the TR of the GH cell with horizontal angle of incident light. The TR was measured by checked the intensity of He-Ne laser beam (λ=632.8 nm) polarized along x-axis after passing through the GH cell. Fig. 4 shows the results of the TR with various concentration of DD vs. horizontal viewing angle. In case of 0 wt% DD [Fig. 4(a)], The TR was not changed with the applying voltages, where it means that there is no absorption with presence of electric field. All graph of fig. 4 shows that the TR increased before the Brewster angle and decreased after the Brewster angle, where it is generally observed in transverse magnetic field (TM) mode [10]. When the concentration of DD is 2.5 wt% [Fig. 4(b)], the TR of GH cell was changed by applying the voltages with a greater horizontal viewing angle. Especially, the biggest gap of TR between non-applied voltage and applying is about 50 % at 45° [Fig. 4(b)]. It means that GH cell shows good performance to switch NV and WV mode. In case of 5.0, 10 wt% DD [Fig. 4(c)-(d)], the magnitude of TR decreased due to increasing the guest DD. Because the more DD contents increased, the higher absorption of DD increased, resulting in decreasing of TR.

4 CONCLUSIONS

We focused on the experimental demonstration of VSA using the GH cells and investigated the effect of concentration of the guest DD in GH cell. To confirm the dependence of VSA property on concentration of DD in GH cell, we experimentally measured the order parameter *S*, extinction coefficients, transmittance (TR) of GH cell fabricated with a various concentration of DD. As the results, the extinction coefficients of GH cell increased with greater the concentration of DD and the extinction between the NV and WV mode was increased.

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