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Red color filter in an organo-soluble polyamide matrix for liquid crystal displays

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Abstract

A red color filter was laminated from a solution of red color pigment and an organo-soluble polyamide, based on 1,4-bis(3,4-dicarboxyphenoxy) benzene dianhydride (HQDPA) and 2,2′-dimethyl-4,4′-methylene dianiline (DMMDA). The red color filter in a polyamide matrix with negative birefringence plays an important role in twisted nematic liquid crystal displays (TN-LCDs). The red color filter, and also compensation films, extend the viewing angle of LCDs. © 1997 Elsevier Science S.A.

Keywords: Optical properties; Polymers

1. Introduction

All twisted nematic liquid crystal displays (TN-LCDs) suffer from poor performance at wide viewing angles because of the difference in the path length of light through the liquid crystal (LC) layer viewed at high angles versus that viewed at near–normal angles to the display plane. A few methods have been proposed to overcome the problem, such as amorphous TN-LCD [1], curvature aligned TN-LCD [2] and compensated TN-LCD [3,4]. Color filter is another issue in the LCD field. Three basic color segments are formed independently. Previously, extension of viewing angle and color filter were treated separately. In this paper, we combine them by using an organo-soluble polyamide thin film as compensation film and matrix of the color filter.

2. Experimental

2.1. Materials and film formation

The process of polyamide synthesis and its molecular weight characterization have been described elsewhere [5]. The red pigment (C.I. 12150) was provided by Shanghai Pigment Developing Institute (China). The mixed solution of the polyamide and red color pigment (< 20 wt.%) in *N*,*N*-dimethyl acetamide (DMAc) was clarified through a 20–40 μm glass filter. Red color filter was coated on a glass substrate. The solvent was evaporated at 60°C for 2–4 h, and then at 150°C in vacuo for 8 h.

2.2. Transmission

The visible transmission spectra of the polyamide thin film (≈ 5 μm) and red color filter (≈ 5 μm) were taken on a Cary 1E UV–visible spectrophotometer (Varian) in the range of 400–700 nm.

2.3. Iso-contrast of LCD

A normally white (NW) 90° TN cell with a cell gap of 7.0 μm filled with commercial liquid crystal CP 9001-LA

Table 1
Physical properties relevant to LC and LC cell

Liquid				Liquid					
V_{th}^{a} (v)	V_{90}^{b} (v)	cell gap (μm)	R.V.[c]	T_{NI}^{d}	n_e	n_o	$\varepsilon_{\parallel}^{e}$	$\varepsilon_{\perp}^{e}$	$\eta \times 10^3$ (Pa·s)[f]
3.1	4.3	7.0	658	101.8	1.588	1.494	3.4	2.8	19.0

[a] Threshold voltage; [b] saturation voltage; [c] retardation value in nm; [d] transition temperature of nematic to isotropic phase in °C; [e] electric permeability, determined at 1 kHz, 25°C; [f] viscosity at 20°C.

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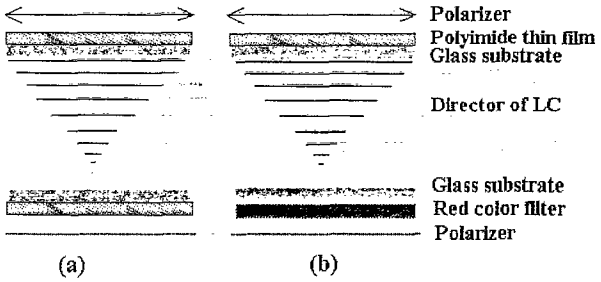

Fig. 1. Sketch of the arrangement for polyamide thin film and color filter in NW-TN-LCD. (a) double layer polyamide thin films compensated NW-TN-LCD; (b) NW-TN-LCD with one polyamide thin film and color filter.

provided by Chisho (Japan) was created for this study. Physical properties relevant to the liquid crystal and the display are listed in Table 1. Iso-contrast maps of the NW-TN-LCD were measured automatically by a computer through the ratio of the luminance of the display conducted at different voltages (0.0–4.5 V). The arrangement of polyamide thin films and red color filter in this study is outlined in Fig. 1.

3. Results

The routine characterizations of polyamide have been detailed previously [5]. Fig. 2 illustrates the transmission of the polyamide thin film and red color filter. It is noted that polyamide thin film can act as a matrix because of its transparency in the visible range, while the red color filter is suitably chromatic, which makes it suitable as a filter.

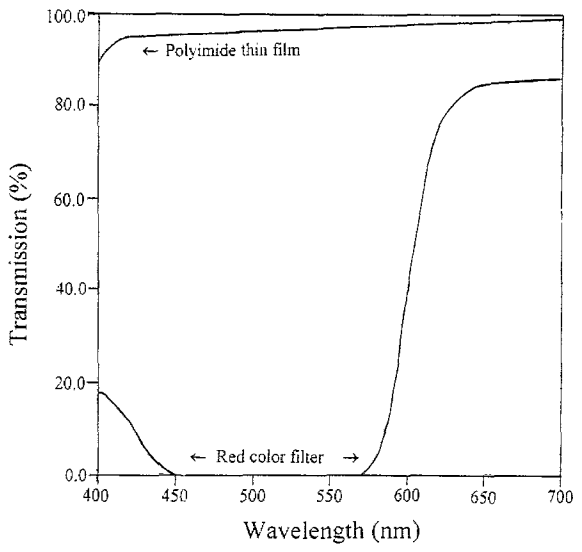

Fig. 2. Visible transmission of polyamide thin film and red color filter.

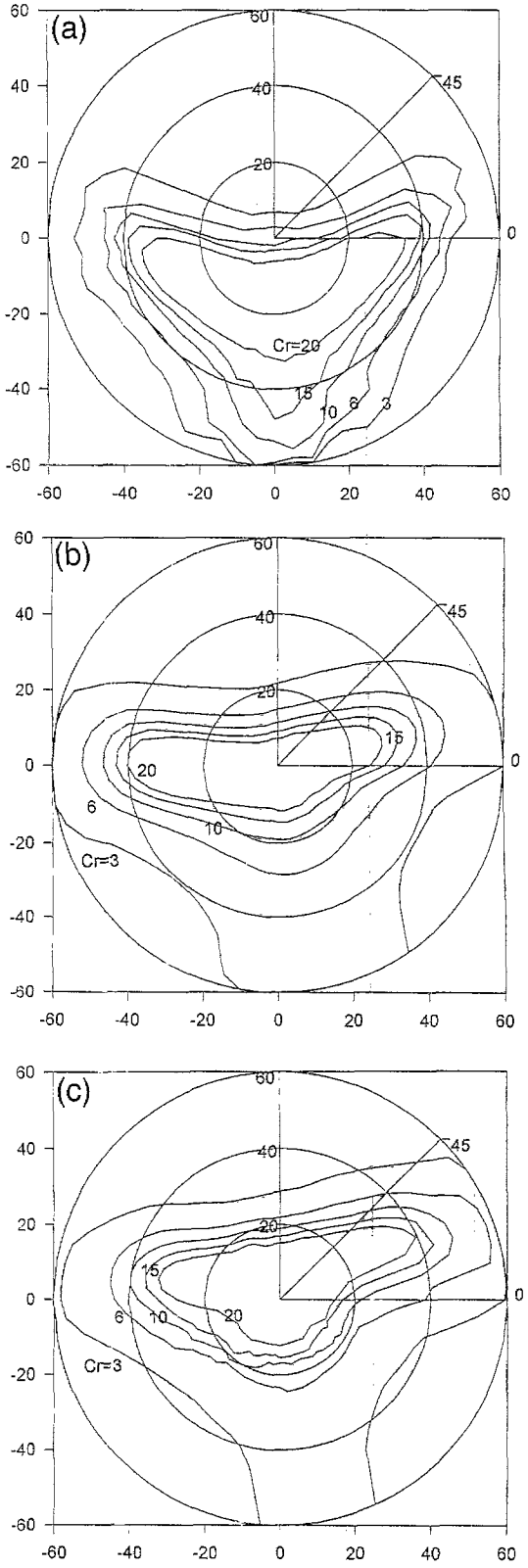

Fig. 3. Iso-contrast maps of LCD. (a) plain NW-TN-LCD; (b) double layer polyamide thin films compensated NW-TN-LCD; (c) NW-TN-LCD with one polyamide thin film and red color filter.

The negative birefringence values of the polyamide thin film and red color filter measured by optical wave guide are both approximately -0.03 μm.

Compensation of polyamide thin film for NW-TN-LCD is based on the following equation:

$$d_1 \Delta n_1 + d_2 \Delta n_2 \rightarrow 0 \quad (1)$$

where 1 and 2 denote liquid crystal cell and compensation film respectively, while d and Δn are the thickness and birefringence of the media.

Double layer polyamide thin films compensate the display partially because their retardation value is approximately -300 nm, while the retardation value of LC cell is 658 nm. Comparing Fig. 3a with b, it is easily seen that polyamide thin films can be used to compensate for NW-TN-LCD to extend viewing angle.

Fig. 3a, b and c suggest that the red color filter in the polyamide matrix functions as a polyamide thin film to extend viewing angle, regardless of the red color pigment in it. The red color filter allows color displaying without disturbing the compensation effects of the polyamide matrix film. The extension of the viewing angle and color display can be unified perfectly as shown in this study.

4. Conclusion

Red color filter in polyamide matrix can be used to achieve red color displaying, and polyamide thin films play dual roles as the matrix for color pigment and also as compensation films to improve display quality. Extension of viewing angle and color display matrix can be solved jointly by organo-soluble high performance polyamide thin films with negative birefringence. Researches on other color filters in polyamide matrix are going on. It is believed that similar results can be obtained.

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References

[1] T. Toko, T. Sugiyama, K. Katoh, Y. Limura, S. Kobayashi, J. Appl. Phys. 74 (1993) 2071.
[2] X. Shao, X. Huang, Z. Ling, Z. Wang, K. Ma and T. Yu, SID'95 Digest, pp. 532.
[3] N. Kimura, Y. Ishii and S. Kozaki, US Patent 5,044,732 (1991).
[4] F.W. Harris and S.Z.D. Cheng, US Patent 5,344,916 (1994).
[5] B. Li, T. He and M. Ding, Polym. Adv. Tech., Accepted for publication.