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The role of reactive monomer in PI-free technology for the alignment ability and image sticking performance

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Abstract
Polyimide-free technology is a technology in which an additive can replace polyimide film to align LC molecules. In this technology, the additive added in liquid crystal (LC) host can not only affect the alignment behavior, but also affect the reliability of the panel, such as image sticking. Because the polymer is polymerized from the additive in LC, the system of the additive is very important. In this paper, we studied the alignment and image sticking performance fabricated by two different additive systems:1. the mixed system of additive and reactive monomer; 2. the single additive system. From the results of cell and 28" panel, we can conclude that the mixed system has similar alignment ability and voltage holding ratio to the single additive system, however, has better image sticking performance than the single additive system.

1. Introduction

Liquid crystal displays (LCDs) are the most popular type of flat-panel displays and are used in television sets, notebook computers, smartphones, tablets and so forth because they have features such as high resolution, low power consumption. So far, the LCDs have usually used a twisted nematic (TN) mode [1], in-plane switching mode [2], fringe-field switching mode [3], multidomain vertical alignment (MVA) mode [4] and patterned vertical alignment (PVA) mode [5]. Among these modes, vertical alignment (VA) mode has a significantly high contrast ratio because vertically aligned liquid crystal (LC) molecules induce little retardation. Among the VA modes, polymer-stabilized VA mode has get considerable interest for their fast response time, low power consumption, and wide viewing angle. To achieve VA, VA layers, which are mainly made from polyimides having side chains, are usually prepared on a pair of substrate [6]. The preparation of the VA layers usually requires large amount of solvent, high–temperature operation for post-baking and cleaning process. Recently, conventional alignment layer-free technologies have been proposed [7,8] and some of them have been for VA.

The key factor of the PI-free technology is the additive system in LC host, which not only plays the role of alighnment, but also affects the electro-optical property and reliability of the panel.

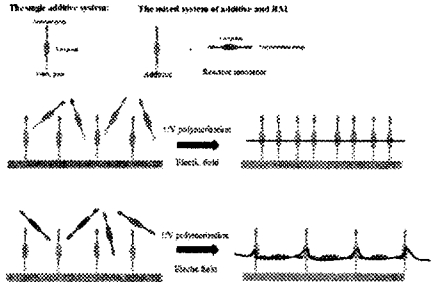
In our previous work, we have demonstrated a polymer-sustained vertical alignment (PSVA) panel without conventional alignment layer. However, the effect of different additive systems on the alignment ability and reliability of panel is not studied clearly. In this paper, we compared the mixed system of additive and reactive monomer (RM) with the single additive system.
From the results, we can find that the mixed system showed similar alignment ability and voltage holding ratio (VHR) with the single additive system. However, the mixed system had better image sticking performance than the single additive system. From the pretilt angle shift, it can be concluded that the mixed system of additive and RM had better pretilt stability than that of the single additive system.

2. Experiment

The PI-free liquid crystal was purchased from JNC, DIC or Merck Corp. The concentrations of additive is about 0.1~2.0% and the concentrations of the reactive monomer is about 0.1~2%. To evaluate alignment performance, the 10*10 VA cells and 28" panel were fabricated by sandwiching the nonpatterned ITO glass (downward one) and the multidomain electrode substrate (upper one). The cell gap of the fabricated cell and panel were maintained to be 3.2μm. The intensity of the UV light in the wavelength range from 300 to 365 nm was 1.32 mW/cm^2. The exposure energy was adjusted in the range from 80 to 800 mJ/cm^2.

3. Results and discussion

The additive and RM molecule structures, the different additive systems used for the PI-free LCD and the diagram of the polymerization process were shown in scheme 1. The additive structure containd 4 groups: 1. The alignment group;
2. The core group; 3. The polymerization group; **4**. The polarity group. The RM structure is the normal structure used in polyimide-aligned PSVA. The polymerization process of two different additive system were same to study the effect of materials to alignment and reliability performance.



Scheme 1: Two additive system used for the self alignment LCD and the diagram of the polymerization process

First, the cells without the conventional alignment layer were proposed (Fig. 1). From the potographs of the PI-free cells under crossed polarisers, it was found that both the cells fabricated by the mixed system (additive + RM) and by the single additive system showed dark states without applying any electric fields. This indicated that the LC molecules were vertically aligned in initial states. When the electric field (7 V) was applied across the PI-free cell after polymer stabilization, disclination line were not appeared in the cells with different additive systems. This results clearly indicate that the cells with different additive systems showed the similar alignment ability.

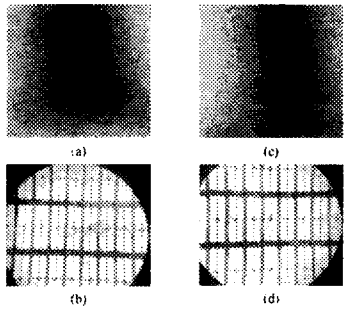


Figure 1: The dark state and the alignment status of the cells fabricated by the single additive system (a-b) and the mixed system (c-d)

Then the voltage holding ratio (VHR) was meatured. Figure 2 showed that the cells with different additive systems had similar VHR value of above 97% at 60°C , which reached the same level compared with the cell with polyimide alignment layer.

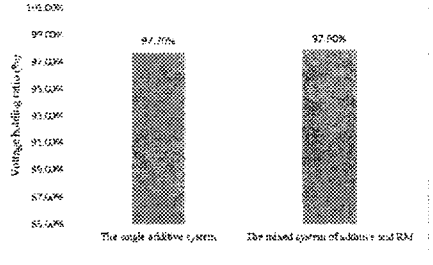


Figure 2: The value of different additive systems

Then PI-free TV panels of 28 inch were developed, and the alignment (Fig. 3) and image sticking perfomance (Fig. 4) stressed at 40°C for 72 h were meatured. Fig. 3 exhibited that both two kinds of 28" panels fabricated by different additive systems showed good alignment ability similar to 10*10 cells.

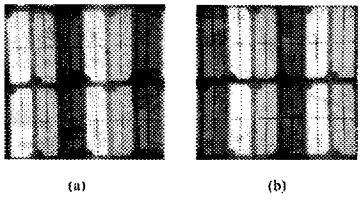


Figure 3: The alignment image of 28" panel fabricated by mixed system (a) and single additive system (b)

Figure 4 showed the IS photograph of panel stressed at 40°C for 72 h. It could be clearly found that the panel with single additive system had obvious IS image and no IS image was found in the panel with mixed additive system. The value of Just Noticeable Difference (JND) showed more explicit information of the IS performance: the JND value of 28" panel with mixed system was 0 and the the JND value of 28" panel with single additive system was biggere than 4. This shows that the mixed system has better IS performance than that with only additive system.

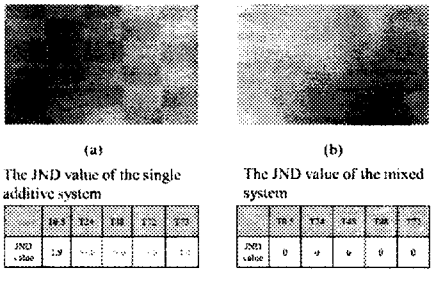


Figure 4: The photograph of the 28" panel stressed at 40°C for 72 h fabricated by the single additive system (a) and the mixed system of additive and RM (b) at 0 gray

Many cause affects the IS phonomenon. To analyze the factor of materials, we meatured the pretilt angle shift of black area and white area. Fig. 5 showed that the better IS performance of the mixed system was derived from the better pretilt angle stability. We also use test cell to measure the pre-tilt angle of LC at alignment. Test cell is designed to measure electrical and optical characteristics easier, because it has no TFT. From the pretilt angle shift of test cell, we could find that the measurement result of pre-tilt angle shift by test-cell match with that of real panel.

Then we concluded that the mixed system (additive + RM) had better pretilt angle stability due to better polymer density than the single additive system.

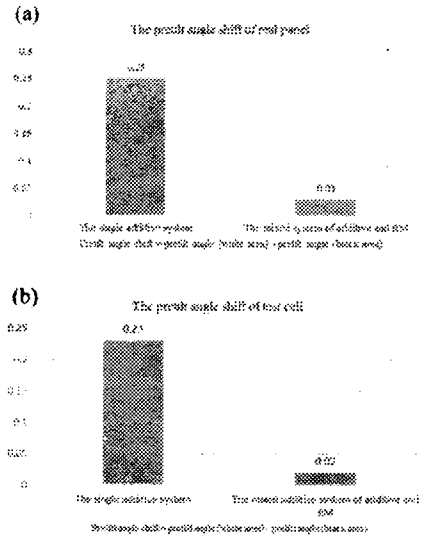


Figure 5. The pretilt shift of the panel (a) and test cell (b) stressed for 72 h.

4. Conclusions

In conclusion, we studied the role of RM in the alignment and image sticking performance. From the study, we can find that the RM has no obvious effect on the alignment ability, and the cell with single additive system showed similar alignment status with that of mixed systems. However, the 28" panel with mixed system of additive and RM showed better image sticking performance than the panel with single additive system. And the data of pretilt angle shift demonstrated that the polymer formed by the mixed system of additive and RM had better pretilt angle stability. Our work advance the development of PI-free technology and provides insights into the development of the material of PI-free LC.

5. Acknowledgment

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