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The controllable of alignment state of polyimide-free liquid crystal displays by adjusting parameter of process technology

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1. Introduction

Nowadays, liquid crystal displays (LCDs) have attracted considerable attention due to their special properties, including high contrast[1], high transmittance[2], rapid response[3], *etc.* LCDs are widely used in information-oriented society, such as television sets , notebook computers, digital signal, etc. To date, various LC modes are used to fabricate LC device, such as twisted nematic (TN) mode[4], in-plane switching (IPS) mode[5], fringe-field switching (FFS) mode[6], polymer-stabilized vertical alignment (PSVA) mode[7]. Among these various modes, PSVA mode have a significantly high contrast ratio due to LC molecules are vertically aligned with the help from vertical alignment (VA) layers. Polyimide layers (PI) are widely used as VA layers in conventional LCD modes for LC initial alignment.. However, the preparation of VA layers usually requires large amount of chemical solvent, high temperature during post-bake, cleaning possess. Otherwise, some technology margin is limited by PI layer. Therefore, it is necessary to develop polyimide- free technology in LCD fabrication process to avoid risk, cost reduction and enhance performance.

In this report, we systematically investigated the influence of the concentration of additive, the routes and temperature of possess, liquid crystal drop filling pattern and diffusion distance on the polyimide-free liquid crystal display. We explores a series of LC cells containing SVA additive with different concentration, including mass ratio of 1 %, 2 %, 3 %. Adjusting process temperature and routes, we raised temperature at 120 °C before UV light irradiation, then compared alignment force variation at different concentration of additive. We also investigate the effect of additive diffusion distance on polyimide-free liquid crystal display by changed LC drop filling pattern. The obtained LC cells were characterized and tested using microscope, liquid crystal reliability measuring instrument. In this report, we will describe the alignment state, voltage holding property(VHR), and electro-optical property of SVA-LC cells. We presume the inner relationship among alignment force, additive concentration and diffusion distance. The self alignment force will decrease with diffusion distance increasing, increase with concentration increasing.

2. Results and discussions

To improve alignment state, innovation process was applied in this study, added heating process before UV light irradiation. As shown as figure 1, it can be clearly observe edge light-leaking and light spot before heating. After heating at 120 °C for 1 h, LC cells' light spots were significantly reduced and present well alignment state. Adjusting additive concentration from 1 % to 3 %, light spots and alignment state can be improve before heating. After heating, light spots and alignment state can all further improve, LC cells present well vertical alignment state.

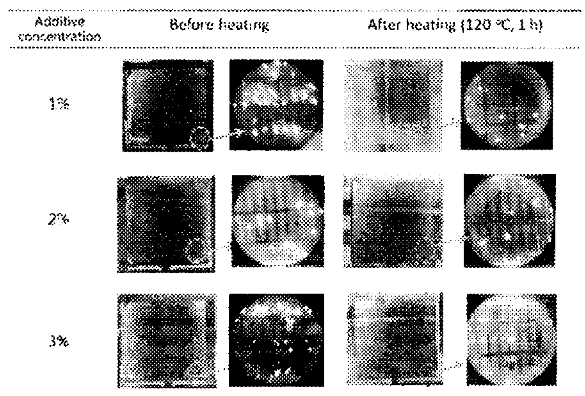
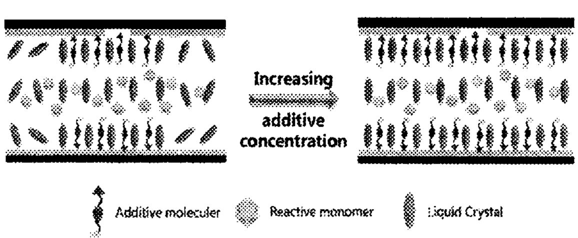


Figure 1: The comparison images of vertical alignment state before and after heating with different concentration additive



Scheme 1. Schematic illustrations of synthetic procedure of vertical alignment LC cell

The presume mechanism which significantly improved alignment state is the arrangement of additive is the key influence factor to maintain LC molecule vertical alignment state, shown as scheme 1. With increasing additive concentration, more LC molecule will maintain vertical alignment with the additives' help. The alignment force become stronger with additive concentration increasing. Then, molecule and additive will rearranged during heating process. The high concentration additive will be equally distributed in LC cells, each LC molecular will esthetic vertical alignment force and maintain

vertical alignment state. In a word, additive concentration increasing and heating process prompt LC molecule esthetic balance and strong vertical alignment force, thus LC cells represent well alignment state.
At the same concentration additive condition, additive diffusion distance is another important factor in this study. Therefore, different LC one drop filling (ODF) patterns were employed, as shown as figure 2 a, b. The same LC drop counts in pattern A and pattern B , the difference of two patterns is distance between first LC drop filling location with seal side location, pattern A is 20 mm, pattern B is 10 mm. Figure 2 c shows LC cells with different ODF pattern present different dark state and light state. LC cell using pattern A can clearly observe edge light-leaking at dark state. At bright state, edges of cell cannot maintain well alignment. The images taken by microscope clearly indicate LC molecule disorderly arrangement at edge area. In contrast, LC cell using pattern B shows well alignment edge and middle at dark and bright state. Before and after UV light irradiation, voltage holding property (VHR) of LC cells were tested, shown in figure 3. After UV light irradiation, LC cells with pattern A or pattern B will keep high VHR, high VHR will benefit of device reliability.

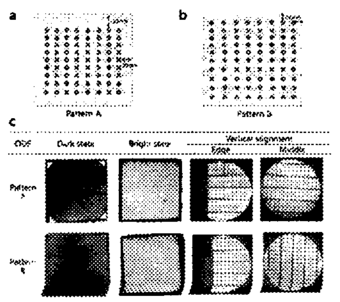


Figure 2a: schematic illustrations of ODF pattern A, the distance between seal and first LC drop is 20 mm
Figure 2b: schematic illustrations of ODF pattern B, the distance between seal and first LC drop is 10 mm
Figure 2c: observation images by different ODF pattern at dark and bright state, and vertical alignment images at edge and middle area

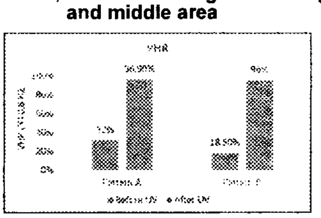


Figure 3: The VHR data of pattern A and pattern B before and after UV irradiation

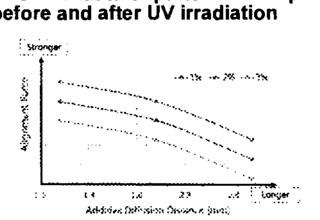


Figure 4: The trend line of alignment force changed with adjusting additive diffusion distance and additive concentration

According to the above data, the inner relation among alignment force (AF), additive concentration (C) and additive diffusion distance (D) is shown as figure 4. The self-alignment force will decrease with diffusion distance increasing, increase with concentration increasing. Again assuming that relation follows inclusion theory, it follows that equation (1).

$$AF \propto C/D \quad (1)$$

3. Conclusion

In this report, we systematically investigated the influence of the concentration of additive, the routes and temperature of possess, liquid crystal drop filling pattern and diffusion distance on the polyimide-free liquid crystal display. The inner relationship among alignment force, additive concentration and diffusion distance was presumed. The self-alignment force will decrease with diffusion distance increasing, increase with concentration increasing.

4. Acknowledgements

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5. References

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