P-127: Stabilization of Azodye Alignment Layer for Liquid Crystal Display

Lishuang Yao, Tao Du, Vladimir Chigrinov, and Hoi Sing Kwok
Dept. of Electronic and Computer Engineering, Hong Kong University of Science and Technology, Clear Water Bay, Kowloon, Hong Kong

Lishuang Yao and Li Xuan
State Key Laboratory of Applied Optics, Changchun Institute of Optics, Fine Mechanics and Physics, Chinese Academy of Sciences, Changchun, PR China

Abstract
In this paper, we explore novel method of fabricating novel stable alignment layer for liquid crystal display. Large azimuthal anchoring energy and alignment quality comparable to that of rubbed polyimide film is obtained without using a contact process. The poor photostability known for azodye materials is overcome with the additional introduction of photocrosslinking material.

1. Introduction
Nowadays photoalignment [1] technology shows great potential for its advantage instead of rubbing method among various technologies. Due to its non-contact nature, photoalignment eliminates generation of dust and electrostatic charges, provides excellent alignment uniformity, and an easy way for controlling liquid crystal (LC) alignment [2]. It is irreplaceable in a number of new developments when LC alignment should be induced in closed volumes, on curved surfaces, and on the surfaces of microscopic scale used, for example, in optical communication devices.

However photoalignment technique suffers some special problems such as low photostability, relatively weak anchoring energy and pronounced image sticking. Among them, photostability of LC alignment layers play a crucial role in affecting the lifetime of LCD. Photocrosslinking material gives the best photostability like cinnamates and coumarines [3]. These materials, however, frequently demonstrate insufficient thermal stability and weak anchoring energy. On the other hand, one of the highest degrees of thermal stability of LC alignment provided photoaligning diazodyes [4]. But LC alignment induced by these dyes is not photostable. The alignment of LC in the filled cells could be easily changed by light in visible spectral range [5].

The attempt to improve photostability of diazodyes was made [6], which reactive group capable of crosslinking was added to the end of dye molecule. However this idea took long time and high cost to synthesize and the alignment of LC was degraded due to the attached terminal groups. Hence a more easier and efficient method to stabilize the dye material should be explored.

In this work, our method is to mix photocrosslinking monomer with azodye material together to be used as alignment layer for LC. Both two materials is linear structure with low molecular weight, avoiding the phase separation. With proper concentration for the mixture we could get a fine alignment film same as with pure azodye material. After exposure with two steps in two special absorption bands, the good quality of azodye material was retained and the high photostability of crosslinking material was also introduced to this mixture alignment film. Hence an easy and efficient way to stabilize azodye material is successfully obtained as reported here.

2. Methodology

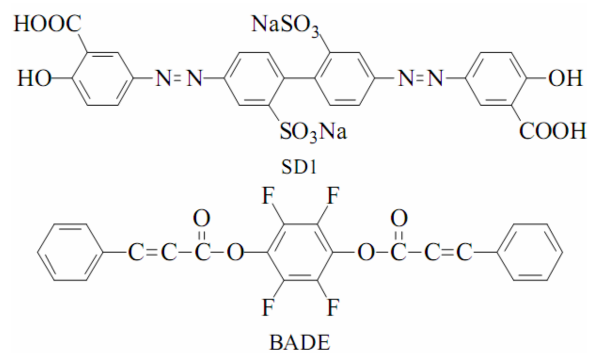
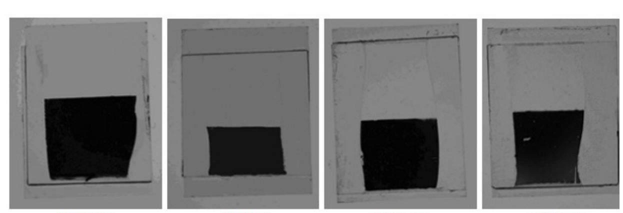


Figure 1 Chemical structures of SD1 and BADE.

Figure 1 is the structure of azodye material (SD1, DIC Corp.) and photocrosslinking material (BADE, provided by CIOMP) used in this work. The solution with different concentration was obtained by mixing with SD1 solution and BADE solution both in DMF. Photoalignment substrate coated with SD1 and BADE is illuminated by a polarized blue LED light (450nm, 70mW/ cm^2) and UV lamp (oriel 6925NS, 365nm, 9mW/ cm^2) for two steps with 1 minute and 5 minutes respectively to form the stable layer. After assembling with 10μm spacer, LC E7 from Merck is injected. Cell with half twisted mode and half parallel mode was fabricated. Strong blue LED light (Intensity = 70mW/cm^2) was used to expose cell to check its photostability.

3. Results
After preparing different solution of mixture with two materials, each kind of film prepared by special solution was fabricated after exposure in same condition to get different alignment layers. Each alignment film was fabricated in half parallel mode and half twisted mode. Figure 2 shows the performances of LC alignment on different layers with several concentrations. It is clear that the introduction of BADE into SD1 material does not degrade the alignment quality. When the mixing ratio in weight between SD1 and BADE, denoted as S and 4F

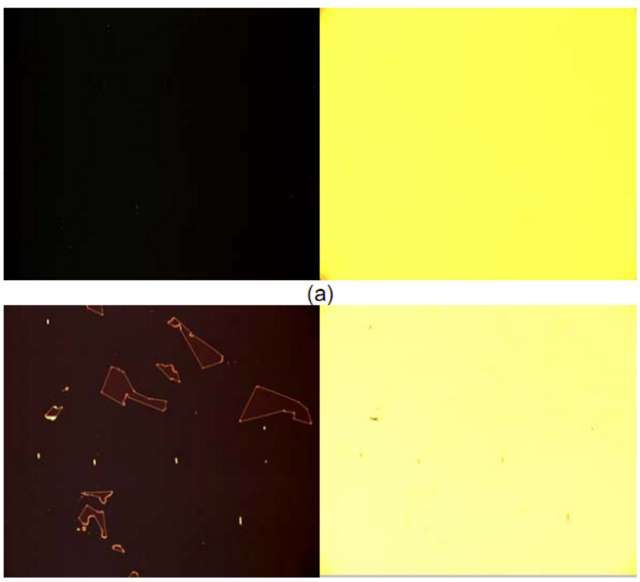


a)SD1 b)9-1 c)8-2 d)6-2

Fig.2 Photos of LC alignment on different layers.

respectively in the following of this article, is 9-1, we can see the alignment quality almost attained in the same level as good as on pure SD1 material. When the mixing ratio of S-4F is 8-2, it is seen that the alignment is the same with that of 9-1. Only when the content of 4F is high up to 25%, S-4F= 6-2, the mixture alignment film also could attain fine alignment quality except some small defect appeared. The appearance of defect may be caused due to large content of 4F material, when phase separation tends to happen. Hence for the following test, we chose S-4F=8-2 as the optimal concentration.

Figure 3 shows the detailed information for the performance of LC on mixture alignment layer with S-4F= 8-2. Fig.3 (a) and (b) is the photos of dark and bright state in the parallel and twisted cell respectively, under microscopy with 100 times magnification. It is shown that the alignment is fine without any obvious defect even it is zoomed in 100 times. And this quality of alignment could meet the request for the real display application.

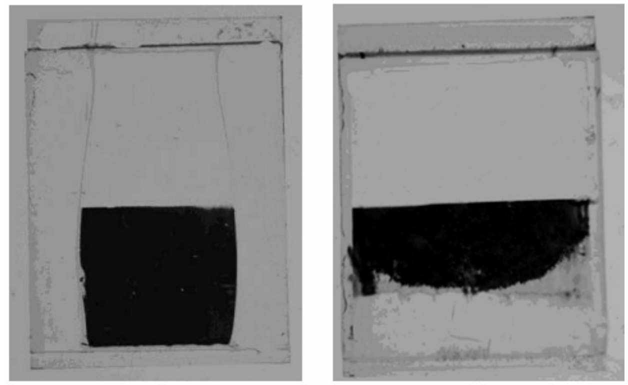


(a)

(b)

Figure 3 Microscopic photos of alignment in (a) parallel/(b) twisted cell on film S-4F=8-2.

After confirming alignment quality, the resistivity against light irradiation is checked here. In real production, every LCD was fabricated with polarizer which could cut off the light in ultraviolet region. Hence here in order to study the photostability more close to ambient environment, we choose 450nm, wavelength exists more than UV light in ambient condition and also harmful to azodye material, as the probe light to check the alignment stability. Figure 4 summarized the photostability contrast for alignment film S-4F=8-2 and pure SD1 layer. Fig.4 (a) is the photo of cell with alignment layer S-4F=8-2 after 20 minutes irradiation with LED light (Intensity = 70 mw/cm^2). It shows that no obvious defect caused by unpolarized light irradiation is seen in this cell. However when it is compared to the cell on pure SD1 alignment layer, different domains formed by unpolarized light exposure is seen inside whole cell as shown in Fig.4 (b). It means after 20 minutes unpolarized light exposure,



a) b)

Figure 4 Photos of cells after exposure: a)S-4F=8-2;b)SD1.

the LC alignment on pure SD1 was damaged at all. Hence it is concluded that the mixture alignment film with S-4F=8-2 actually improved the photostability of pure SD1 material. And the test here strong LED light is used to check the stability and show no obvious damage to the alignment of LC. So when it is used in real life which the light is much more weak than the LED light, the lifetime for the LCD on mixture alignment S-4F= 8-2 must be longer and meet the application in display field.

Since no additional layer is needed to protect azodye material, the manipulation process could be easily simplified and the effect is also better compared to complicated fabrication process [7].

4. Impact

In summary, this paper proposes a new method to stabilize azodye material which shows good alignment property. With mixing stable photocrosslinking material into mature azodye material, a fine alignment film is obtained. It exist not only the good alignment performance derived from azodye material but also the fine photostability from crosslinking material. Since no additional layer is needed and no complicated structure is needed to synthesize and optimize, this method explores an easy way to fabricate stable photoalignment film for liquid crystal display. Even under strong LED exposure, the alignment film could attain good alignment for at least 20minutes, meaning it is stable enough when it is used in day life with much weaker blue light.

5. Acknowledgements

This work is supported by financial support of HKUST under grant HKUST CERG 612409, CERG RPC07/08.EG01and CERG 612208/614408.

6. References

[1] P. J. Shannon, W. M. Gibbons, S. T. Sun, “Patterned optical properties in photopolymerized surface aligned liquid-crystal films,” Nature **368**,532-533 (1994).

[2] M. Schadt, K. Schmitt, V. Kozenkov and V. Chigrinov, “Surface-Induced Parallel Alignment of Liquid Crystals by Linearly Polymerized Photopolymers,” Jpn. J. Appl. Phys. Part1 **31**, 2155-2164 (1992).

[3] M. O’ Neill and S. M. Kelly, “Photoinduced surface alignment for liquid crystal displays,” J. Phys. D **33**, R67-84, (2000).

[4] H. Akiyama, T. Kawara, H. Takada, H. Takatsu, V. Chigrinov, E. Prudnikova, V. Kozenkov, H. S. Kwok, “Synthesis and properties of azo dye aligning layers for liquid crystal cells,” Liq. Cryst. **29**, 1321-1327, (2002).

[5] A. Muravsky, A. Murauski, X. Li, V. Chigrinov, H. S. Kwok, “Optical rewritable liquid-crystal-alignment technology,” J. Soc. Inf. Disp. **15**, 267-273, (2007).

[6] V. G. Chigrinov, V. M. Kozenkov, H. S. Kwok, “Photoalignment of Liquid Crystalline Materials: Physics and Applications” Wiley, New York, (2008).

[7] O. Yaroshchuk, V. Kyrychenko, Du Tao, V. Chigrinov, H. S. Kwok, H. Hasebe, H. Takatsu, “Stabilization of liquid crystal photoaligning layers by reactive mesogens,” A.P.L. **95**, 02190201-03, (2009).