P-136: Tunable Photosensitivity of Alignment Film for Flexible Liquid Crystal Displays

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Abstract

In this paper, a novel type of photosensitive material used for photoalignment was explored here. After unpolarized ultraviolet light (UV) irradiation in solution, spincoating film with this new material showed fine ability to align liquid crystal (LC) without further exposure. With proper concentration of mixing it to mature azo-dye photoalignment film explored in our lab, the alignment film could give exeellent alignment quality. Furthermore, the photosensitivity of photoalignment film could be tuned up and down in contrast to that with pure azo-dye material. This result is exciting for flexible liquid crystal displays such as optical rewritable electronic paper (ORW e-paper), which makes gray scale of device much easier to achieve with photoalignment films existing tunable photosensitivity.

1. Introduction

Optical rewritable technology[1] is a modified method of azodye photoalignment[2] that possesses traditional high azimuthal anchoring energy, up to 2×10–4 J/m2 and has a unique feature of reversible in-plane aligning direction reorientation, i.e., rotation perpendicular to the polarization of a incident light. An ORW LC cell consists of two substrates with different aligning materials (Fig. 1). One aligning material is

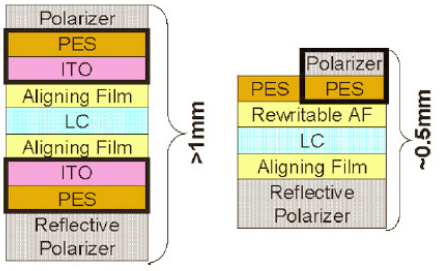

Fig.1 Structure of electrically controlled (left) and ORW (right)plastic displays.

optically passive and maintains the aligning direction on one substrate. The other aligning material is optically active and can change its alignment direction being exposed with polarized light through the substrate. Compared to an electrically controlled plastic display, ORW can be significantly thinner and does not require ITO photolithography and etching on the plastic substrates because electrodes are not required. If the opticallly active alignment layer could be tuned with photosensitivity, then the property such as rewritable time and grey scale of ORW device could be controlled easily.

Nowadays, there are many photo-alignment methods (for example, photo diffusion, photo polymerization, photo isomerization etc) [3-5] which could be used for ORW device. And all the reported photo-alignment methods till date uses polarized light to align the liquid crystal molecules. Present work explores a new method for photo aligning the orientation layer as well as orienting a liquid crystal layer applied to the photoaligned orientation layer showing fine alignment behavior by coating the material named M7. Solution of this dye is exposing to unpolarized light thereby coating it on to substrates allows to imparting self assembled direction to the layer which is same as liquid crystal aligning direction.Consequence to that unusual method for photo alignment using unpolarized light is shown. Interestingly, irradiation is done on the solution itself rather than the substrates compare to all the photo aligning methods reported in the literature, which shows high orderity in solution. Hence, if it is introduced to mature photoalignment film, the high orderity in solution before exposure with linear polarized utraviolet light (LPUVL) may improve the photosensitivity of alignment film. Further more,we have already archieved one mature azo-dye photoaligned material SD1[6-7], which shows excellent alignment quality for optically rewritable devices. Hence, we mix SD1 solution without exposure with M7 soultion after unpolarized irradiation together; and with proper concentration of two material, variable photosensitivity could be obtained. Finally a novel photoalignment film with excellent alignment quality and faster photorespose time than pure SD1 layer for ORW device is archieved.

2. Experimental

The chemical strucuture of new photosensitive material M7 is shows as Fig.2. Initially 0.125% of M7 is dissolved in suitable solvent (in our case we used 1-Methyl-2-pyrrolidinone called as NMP),1% of SD1 is also prepared in NMP. Initial color of M7 solution is orange. This solution is irradiated with unpolarized 365 nm UV (UV intensity 4 mW) for 5 minutes. Take this irradiated solution and spin-coat (800 rpm for 10 s and 3000 rpm for 40 s) this material on to the substrate and after baking at 100 ºC for 30 minutes. Without further irradiation, parallel cell with 5µm thickness (MerckLC E7) is fabricated with this baking substrate.

As to prepare new photoalignment film with tunable photosensitivity, 1% of SD1 with no exposure and 0.125% M7 after unpolarized irradiation is mixed together to get solutions with different concentration of M7. And then is to get spincoat films with condition metioned above,here baking is done at 140 ºC for 30 minutes. To

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confirm the photosensitivity of film under polarized UV light irradiation, photoinduced birefringence measurements were performed. In this work, we shined Ar-Ion laser exhibiting wavelength ~457 nm (UV intensity 4 mW). In this study He-Ne laser beam is used as probe beam (~632 nm), which is not in the strong absorption band of the azo dyes we used. Ar-Ion is used as pumping light. After that is to fabricated parallel and TN cell (5μm thickness,MerckLC E7) with the irradiated photoalignment film, and azimuthal anchoring is measured with the method reported before.[8]

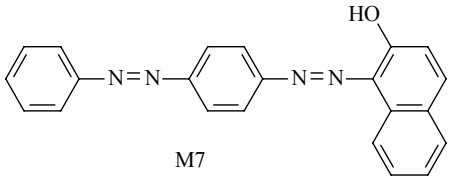

Fig.2 Chemical structure of M7

3. Result and discussions

Fig.3 is the photograph of LC cell under crossed polarizer fabricated with film spincoated with unpolarized UV irradiation in 0.125% M7solution. Consequence to that unusual

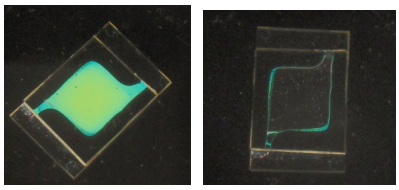

Fig.3 Bright and dark of homogeneous LC cell with M7 solution after unolarized light irradiation

method for photo alignment using unpolarized light is shown. Interestingly, irradiation is done on the solution itself rather than the substrates compare to all the photo aligning methods reported in the literature. Orientational direction of the alignment is self defined and no external agency is necessary.

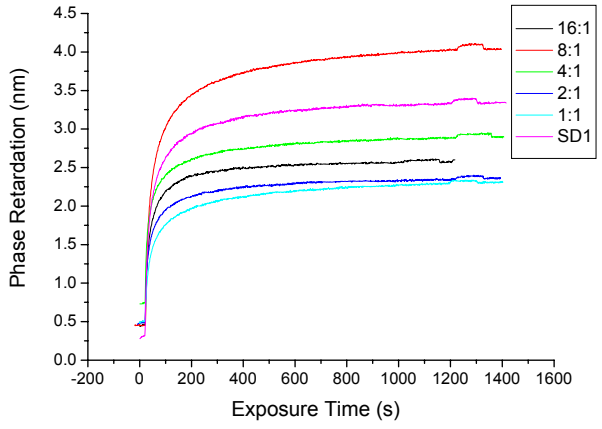

Fig.4 Dependence of photoinduced birefringence with exposure time for films with most content of SD1.

Fig.4 is the photoresponse curve versus exposure time for films with M7 less than 50% (weight). It is seen that when doped with M7 below the 50%, the photosensitivity does show enhancement in contrast to pure SD1, however the change of photosensitivity with increasing weight of M7 is not linear relation. It is interesting to find that only when the ratio of SD1-M7 is 16:1,2:1, 4:1, the films show increase of photosensitivity. But the ratio of 8:1and 1:1 show the slowing down the photoresponse time of the corresponding films.

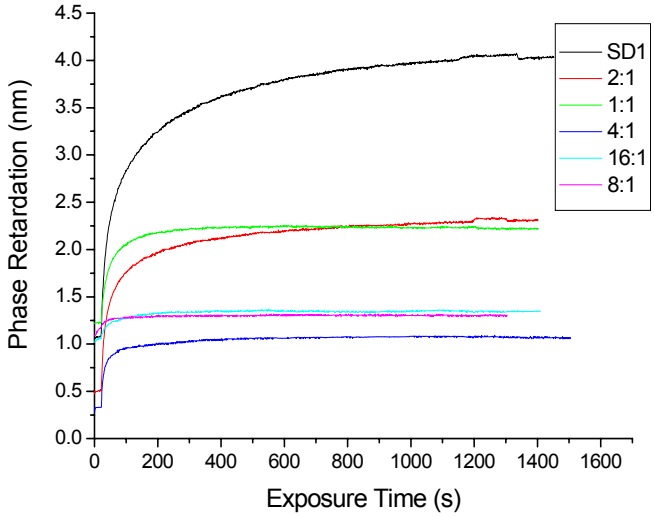

Fig.5 Dependence of photoinduced birefringence with exposure time for different films with most of M7.

Fig.5 is the photoresponse curve versus exposure time for films with M7 more than 50% (weight).

It is interesting to see that when the weight ratio of M7 is larger than 50%, all the films show obvious decrease of the photoresponse time under irradiation. However due to the fewer content of SD1 material, the birefringence of the films is much smaller compared to the films with more SD1 shown in Fig.4. It is possible because of the lower order parameter in M7 solution with concentration of 0.125%. Nevertheless, all the results show that the induction of M7 material into SD1 exactly decrease the photoresponse time of the alignment films.

And all the quantitative information about the increase of photosensitivity is summed in Table 1. It is clear to see that the film with ratio of SD1-M7 16:1 and 1:2 show faster photoresponse time when it is irradiation with UV light, with the tuning up ratio up to 6% and 15.4%.

Table 1 Photosensitivity of films with different ratio of M7.

SD-1/M7	R_{150s}/R_{max}	Tuning ratio
100:1	86.2%	
16:1	91.5%	6%
8:1	84.1%	-2.4%
4:1	89.8%	4.2%
2:1	89.6%	3.9%
1:1	84.7%	-1.7%
1:2	99.5%	15.4%
1:4	90.7%	5.22%
1:8	97.4%	12.9%
1:16	98.9%	14.7%

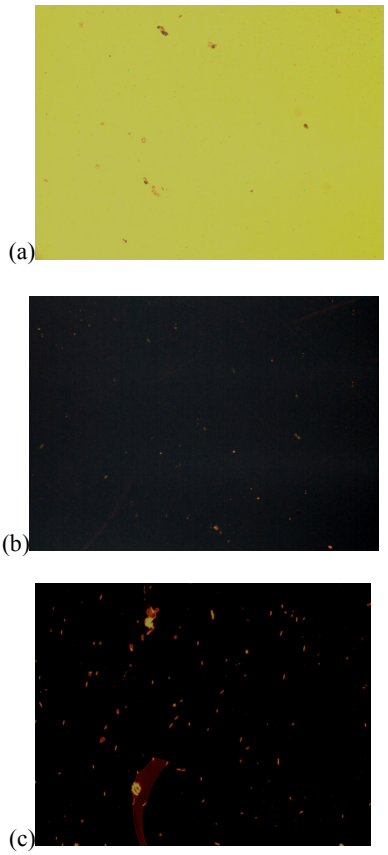

Fig.6 Photographs of parallel (a,b) and TN cell (c) under microscope with crossed and parallel polarizer(SD1-M7 1:2)

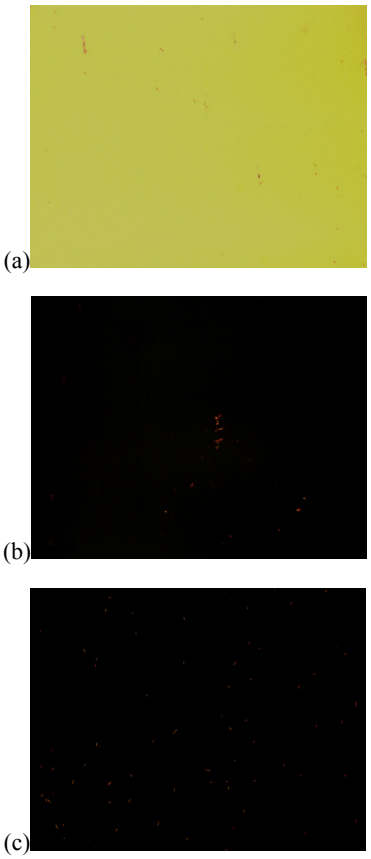

Fig.7 Photographs of parallel (a,b) and TN cell (c) under microscope with crossed and parallel polarizer(SD1-M7 16:1)

Fig.6 and Fig.7 show the photographs of parallel and TN cells with alignment film of SD1-M7=1:2 and 16:1.We can see that when the ratio is SD1-M7=16:1, the alignment films shows excellent alignment quality compared to alignment film with pure SD1 material reported previously[6].

Table 2 gives the value of Wa and photosensitivity of both films with SD1-M7=16:1 and SD1-M7=1:2. Alignment film with SD1-M7=16:1 shows strong anchoring energy as pure SD1photoaligment film and with further increase 6% of photoresponse time. Alignment film with SD1-M7=1:2 shows much better alignment quality compared with film with pure M7 material shown in Fig.3, and the photosensitivity is increased 15.4% in contrast to pure SD1 alignment film.

Table 2 Wa and photosensitivity of films with different ratio of M7 to SD1.

SD-1/M7 (weight ratio)	Anchoring Energy Wa ($10^{-4} \times J/m^2$)	Increase of photosensitivity
16:1	1.71	6%
1:2	0.553	15.4%

4. Summary

In summary, novel photosensitive material M7, which shows extraordinary orientation ability to align liquid crystal with high photosensitivity is explored in this work. Solution of this dye is exposing to unpolarized light thereby coating it on to substrates allows to imparting self assembled direction to liquid crystal aligning direction. Furthermore, with mixing M7 into SD1, the photosensitivity of the corresponding photoalignment film is tunable freely through controlling the concentration of M7 in film. Finally, we get the information that the film with SD1-M7=16:1 shows azimuthal anchoring energy as strong as that with pure SD1 photosensitive material. And the photosensitivity could be tuned up to 6% compared with alignment film with pure SD1. In a word, the photosensitivity could be tuned freely and fabrication process is easy, that it is suitable for high quality optically rewritable devices.

5. Acknowledgement

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7. Prior Publication

There are no prior publications.