

Effects of Humidity and Surface on Photoalignment of Brilliant Yellow*

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Abstract

Controlling and optimizing the alignment of liquid crystals is a crucial process for display applications. Here, we investigate the effects of humidity and surface types on photoalignment of an azo-dye brilliant yellow (BY). Specifically, the effect of humidity on the photoalignment of BY was studied at the stage of: substrate storage before coating; during the spin-coating process; between film coating and exposure; and after exposure. Surprising results are the drastic effect of humidity during the spin-coating process, the humidity annealing to increase the order of the BY layer after exposure, and the dry annealing to stabilize the layer. Our results are interpreted in terms of the effect of water on the aggregation or crystallization of BY. The type of surface studied had minimal effects. Thin BY films (3nm thickness) were sensitive to the hydrophilicity of the surface while thick BY films (30nm thickness) were not affected by changing the surface. The results of this paper allow optimization of the photoalignment of BY for liquid crystal display applications as well a better understanding of the BY photoalignment mechanism.

1. Introduction

Understanding and controlling the alignment of liquid crystals is a critical research area in the display applications. The alignment of liquid crystals (LC) at an interface is generally determined by the surface order of the interface between the LC and the substrate. Currently, the most widely used technique to produce the alignment layer is mechanically rubbing a polymer film.¹ However, this method has some drawbacks, such as introduction of dust particles, generation of static charges, and formation of scratches on the polymer surface. These defects could undermine the quality of displays and increase

the cost for manufacturing. Because of the non-mechanical contact, photoalignment aims to eliminate these problems.²⁻⁴ Photoalignment based on azo-dyes offers an intriguing way to fabricate liquid crystal optical devices due to the low cost as well as the ability to create complex and precise alignment patterns.^{5,6} The azo-dye brilliant yellow (BY) was first studied by West. *et al*, showing it is a good candidate for photo-alignment applications.⁷ Recent work showed that BY can be easily aligned by blue light^{8,9} and utilized to fabricate a thin Pancharatnam lens.¹⁰

For most studies or applications, a BY solution is spin-coated onto a cleaned glass; then exposed to polarized light to induce alignment. Humidity has been shown to have an effect on the wetting of the deposited film during the spin-coating process.¹¹ Because BY is an ionic dye which can be dissolved in water and is susceptible to hydrogen bonding,^{7,12} it is important to pay attention to the humidity during the preparation of BY film. Previous studies showed that the humidification triggered restructuring of the brilliant yellow dispersed in triacetyl cellulose from 1D nematic-like order to anisotropic 2D columnar order, resulting in an increase in the order parameter.¹³ Here, we study the effects of humidity at 4 different stages of the BY deposition and alignment process: substrate storage before coating; during the spin-coating process; BY film storage before exposure; and BY film storage after exposure. Besides the detailed investigation of humidity on the photoalignability of BY, we also demonstrated that we can utilize humidity annealing to increase the order parameter and dry annealing to stabilize the alignment.

To see whether the surface effects the photoalignment of BY, we investigated the BY deposited on several types of surfaces: Indium Tin Oxide (ITO) coated glass, bare glass and glass coated with either a polyvinyl alcohol (PVA) film or a polyimide (PI2555) film.

2. Experimental

Brilliant yellow (BY, molecular structure shown in Figure 1a) dye (purchased from Sigma-Aldrich) was dissolved in dimethylformamide (DMF, anhydrous, 99.8%, Sigma-Aldrich) at 1.5% or 0.1%. The glass plates were pre-cleaned using an ultra-sonic cleaner with detergent (Cavi-Clean liquid detergent) and deionized water (60°C) for 10min, followed by deionized water and isopropanol rinsing; after drying in an oven (90°C), the pre-cleaned glass plates were exposed to UV-Ozone for 10min.

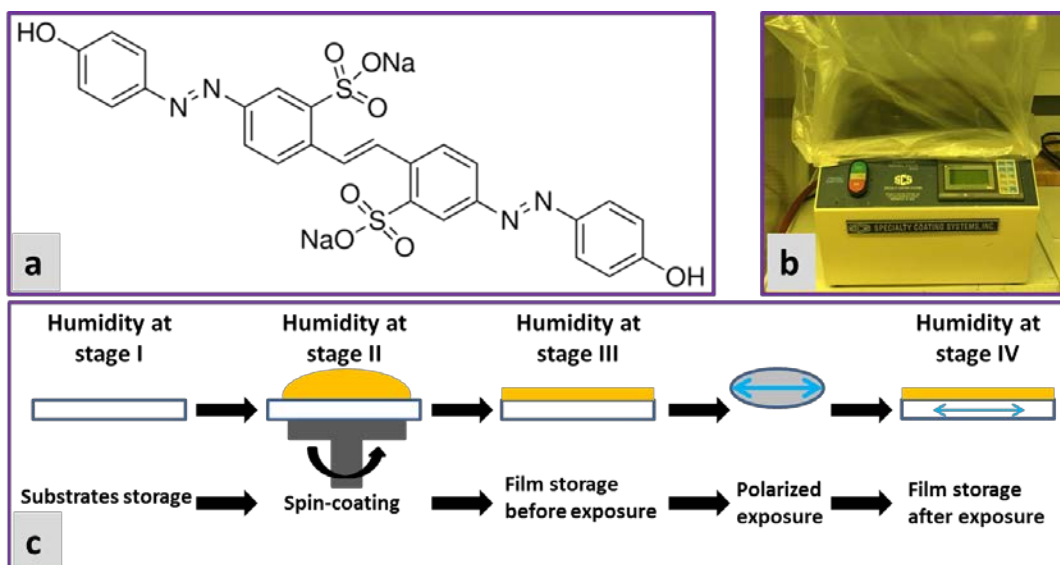


Figure 1. a) Molecular structure of brilliant yellow (BY). b) Photograph of spin-coater area covered with a plastic bag filled with nitrogen gas and humid air to control the humidity. c) Schematic of four stages where the humidity was studied. Humidity at stage I: substrates stored at different humidity before spin-coating; Humidity at stage II: different humidity levels during spin-coating; Humidity at stage III: humidity absorbed by unexposed film; Humidity at stage IV: humidity absorbed by exposed film.

The effect of humidity at 4 different stages was studied, as shown in the schematic (Figure 1c): Humidity at stage I - glass substrates stored at different humidity before spin-coating; Humidity at stage II - different humidity levels during spin-coating; Humidity at stage III - humidity absorbed by BY films before exposure; Humidity at stage IV - humidity absorbed by BY film after exposure.

For the study of humidity during the spin-coating (humidity at stage II), the spin-coater (Special Coating System model P6700) was tightly covered with a plastic bag (volume = 50L) filled with a mixture of nitrogen (supplied by Airgas) and humid air (35-65% RH) generated by dehumidifier (SOLEUSAIR Model GL-DEH-70F-2) to adjust the environmental humidity surrounding the spin-coating area, as shown in Figure 1b. The humidity was monitored by humidity meter (Acu-Rite) sitting inside the plastic bag. A BY solution (1.5 wt. %) was spin-coated (1500rpm for 30s) onto fresh UV-Ozone cleaned bare glass plates at varied relative humidity (RH) ranges: 27-30%, 40-45%, 46-50%, 50-58%, 52-59%, and 61-65%. After spin-coating, the resulting BY films were baked at 120°C for 10min to evaporate the remaining solvent, and then exposed to polarized blue light (Luxeon Royal blue LED with peak wavelength of 447nm) at 25mW/cm² for 5min. The absorption spectra of these BY films before and after light exposure were measured with a polarized incident light by Lambda 19 UV/VIS/NIR spectra-photometer (Perkin Elmer). The order parameter of aligned BY film was calculated by equation $S = (A_{\perp} - A_{\parallel}) / (A_{\perp} + 2A_{\parallel})$, where A_{\parallel} is the absorbance maximum when the polarized direction of the incident light for spectroscopy is parallel to that of incident polarized blue light for photoalignment; A_{\perp} is the absorbance maximum when the polarized direction of the incident light for spectroscopy is perpendicular to that of incident blue light for photoalignment.

To investigate the role of water absorbed on the glass substrates (humidity at stage I), UV-Ozone cleaned glass plates were kept at high humidity (a sealed box containing water, 80-90% RH) or low humidity (a closed box containing bentonite clay desiccant, <16% RH) for different lengths of time (2.5h, 22h, or 48h) before spin-coating. Then, the glass plates were spin-coated with 1.5 wt. % BY solution at a low humidity (25±2% RH), followed by polarized light exposure without further waiting. The polarized light absorption spectra of these BY films before and after light exposure were measured as well. As for the effect of humidity absorbed by the unexposed BY film (humidity at stage III), firstly three BY films were spin-coated onto UV-Ozone cleaned glass plates at low humidity (25±2% RH). Before polarized light exposure, these BY films were kept at high humidity (80-90% RH), moderate humidity (40-45%RH, experimental dark room controlled by dehumidifier) or low humidity (<16% RH) for different lengths of time (2.5h, 22h, or 48h). Immediately after these specific sitting times, the unexposed BY films were exposed to polarized blue light at 25mW/cm² for 5min, followed by polarized light absorption spectra measurement. As for the humidity absorbed by the aligned BY film (humidity at stage IV), two BY films were first spin-coated at 25±2% RH, and immediately exposed to polarized light. After the polarized spectra measurement, one aligned BY film was kept at high humidity (a sealed box containing water, 80-90% RH) and one was kept at low humidity (a box containing bentonite clay desiccant, <16% RH); their absorption spectra were taken as a specific length of sitting time, such as 2.5h, 18h, 25h and 48h. In all the experiments, the temperature was kept at 25±3°C.

To further investigate the effect of humidity annealing on alignment stability, we compared three aligned BY films – one with humidity annealing (aligned then sitting at high humidity for 48h), one with dry annealing (aligned then sitting in a desiccant-box for 48h) and one without sitting (aligned then immediately processed with stabilizing test). All these BY films were spin-coated onto UV-Ozone cleaned glass plates at low humidity (25±2% RH), followed by polarized light exposure. The stability test was to expose the photoaligned BY films a second (third ...) time with the polarization state of the writing light (50mW/cm²) at 45 degrees to the original exposure direction. If the original alignment can be re-written, the absorbance in both original direction and expected new direction will change. After every stabilizing test, the absorption spectra were measured when the polarized direction of the incident light for spectroscopy was 0°, 45°, 90°, 135° to that of original incident polarized blue light for photoalignment.

The studied surfaces that can be wet by BY-DMF solution include ITO coated glass, bare glass, polyvinyl alcohol (PVA) film, and polyimide (PI2555) film. To prepare PVA film, 1% PVA water solution was spin-coated onto UV-Ozone cleaned glass at 1500rpm for 30s, followed by baking at 100°C for 10min to remove water. To prepare polyimide film, PI2555 (diluted to 1:9) was spin-coated onto cleaned glass at 1500rpm for 30s, followed by soft baking at 95°C for 1min and then hard baking at 275°C for 1 hour. About 0.25ml BY-DMF solution was flooded onto the different substrates (1 inch X 1 inch size) through a 0.2µm filter and spun at 1500rpm for 30s to create a uniform BY layer. At relative low humidity (35-40% RH), BY films with different thickness were created on each surface by spinning down BY-DMF solutions with different concentrations (0.1 wt. % or 1.5 wt. %) at 1500rpm for 30s.

3. Results

3.1 Effect of humidity

3.1.1 Effect of humidity at stage II (during spin-coating process)

The most surprising and greatest effect of humidity was observed when the DMF/BY solution was coated onto the substrate by spinning. A 1.5 wt. % solution of BY dissolved in DMF was spin-coated onto fresh UV-Ozone cleaned glass plates under 6 different humidity ranges: 27-30%, 40-45%, 46-50%, 50-58%, 52-59%, or 61-65%. The humidity was the only varied parameter during this series of experiments. As can be seen from Figure 2, the absorption spectra of these resulting BY films before exposure show peak wavelength shift and/or spectra shape change as the humidity increases from <30% to >60%. The peak wavelength shifts from 402nm to 423nm and a longer wavelength shoulder (around 480nm) appears when the relative humidity is higher than 50%.

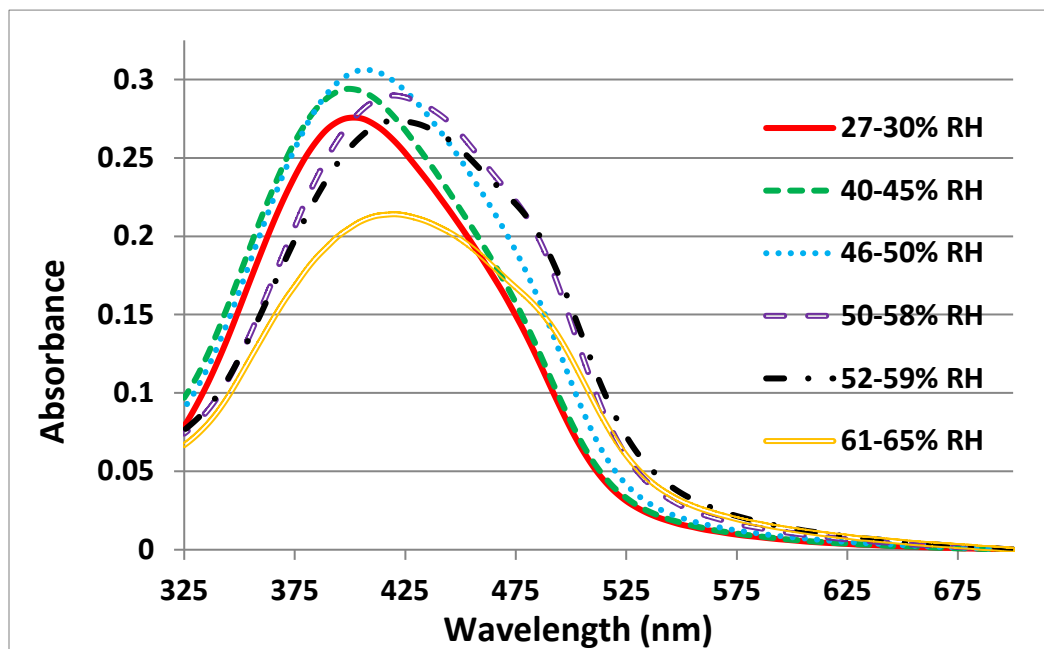


Figure 2. Absorption spectra of these unexposed BY films prepared at different relative humidity levels.

To investigate the effect of humidity on the photoalignment of BY, all the BY films spin-coated at varying humidity were exposed to the same polarized light (25mW/cm² for 5min). The calculated order parameters based on measured absorption spectra after exposure are plotted in Figure 3. The order parameters decreased from 0.8 to 0.18 as the humidity increased from 27% to 50%. No alignment occurred in these experiments when the humidity is higher than 50%.

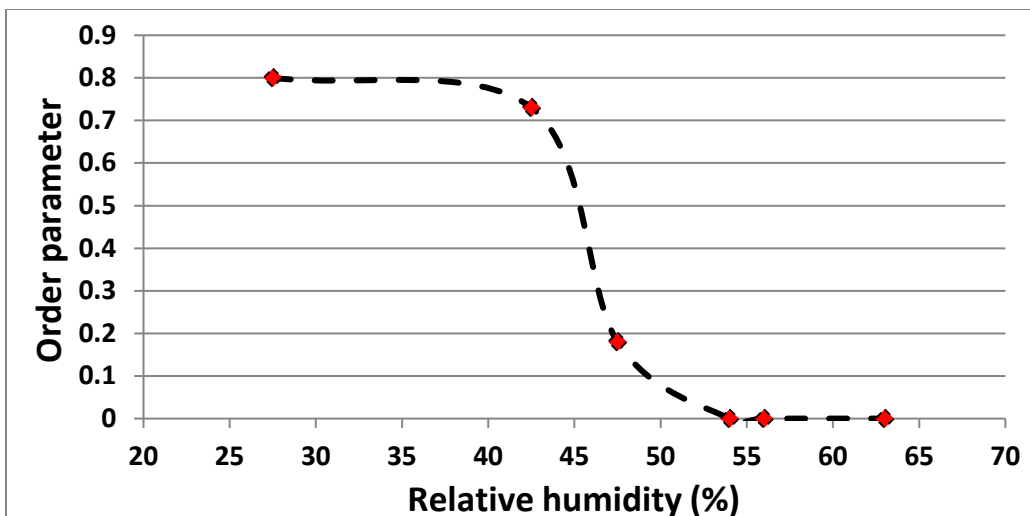


Figure 3. Humidity dependence of order parameters of BY films spin-coated at different humidity.

The dramatic change of order parameter (changed from 0.73 to 0) occurred when the humidity increased from 40-45% to 50-58% during the spin-coating process. The change is also illustrated by their polarized electronic absorption spectra, as shown in Figure 4.

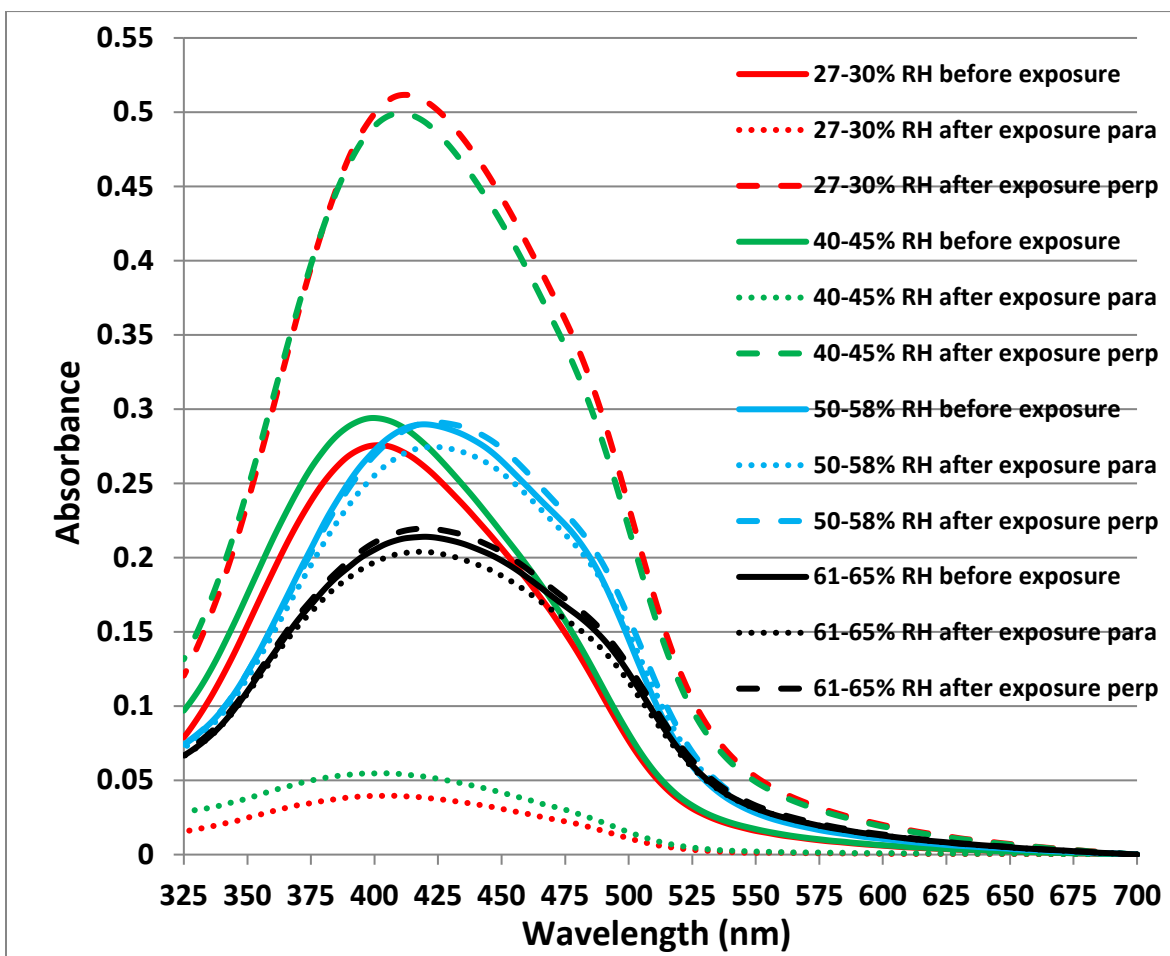


Figure 4. Absorption spectra of BY films spin-coated at four humidity levels (27-30% RH, 40-45% RH, 50-58% RH or 61-65% RH). Solid line curves represent the absorption spectra of unexposed BY films; dot line curves represent absorption spectra of exposed BY films measured when the polarized direction of the incident light for spectroscopy is parallel to that of incident polarized blue light for photoalignment; dash line curves represent the absorption spectra of exposed BY films measured when the polarized direction of the incident light for spectroscopy is perpendicular to that of incident blue light for photoalignment.

For the BY film prepared at 27-30% RH, the unexposed film shows absorbance maximum of 0.275 and peak wavelength of 401nm. After exposure, the absorbance maximum in the parallel direction (A_{\parallel}) decreased to 0.039 while the absorbance maximum in the perpendicular direction (A_{\perp}) increased to 0.511. The averaged value of absorbance maximum in parallel and perpendicular directions is equal to the absorbance maximum of the film before exposure. For the BY film prepared at 40-45% RH, the unexposed film shows absorbance maximum of 0.293 and peak wavelength of 402nm. After exposure, the absorbance maximum in the parallel direction (A_{\parallel}) decreased to 0.05 while the absorbance maximum in the perpendicular direction (A_{\perp}) increased to 0.5. The averaged value (0.275) of absorbance maximum in parallel and perpendicular directions is also roughly close to the unexposed value (0.293). These peak absorbance data measured before and after exposure indicates that the BY undergoes an in-plane rotation during the photoalignment process. Both BY films prepared at 27-30% RH and 40-45% RH show a red-shift of spectra peak wavelength (412nm) when measured in the perpendicular direction, maybe due to the J-aggregation of aligned BY.¹⁴ For the BY films prepared at 50-58% RH and 61-65% RH, both spectra of unexposed film show a red-shift of peak wavelength (423nm) and a shoulder peak around 480nm; however, almost no change in both parallel and perpendicular directions occurs after polarized light exposure.

Besides the absorption spectra differences, we also observed the macroscopic appearances of these unexposed BY films obtained at varying humidity. For the macroscopic observation, the BY films were illuminated on the microscope stage using transmitted backlight, as shown in Figure 5. The BY films prepared at the relative humidity less than 45% look clear (Figure 5a and 5b). As the humidity increased to 46-50%, the resulting BY film shows weak light-scattering, as the light bluish appearance shown in Figure 5c. A clear difference is observed when the BY is spin-coated under 50-58% humidity. This BY film shows strong light scattering (see Figure 5d). At even higher humidity (>60%), the obtained BY film shows non-uniform coating as well as strong light scattering, as shown in Figure 5f.

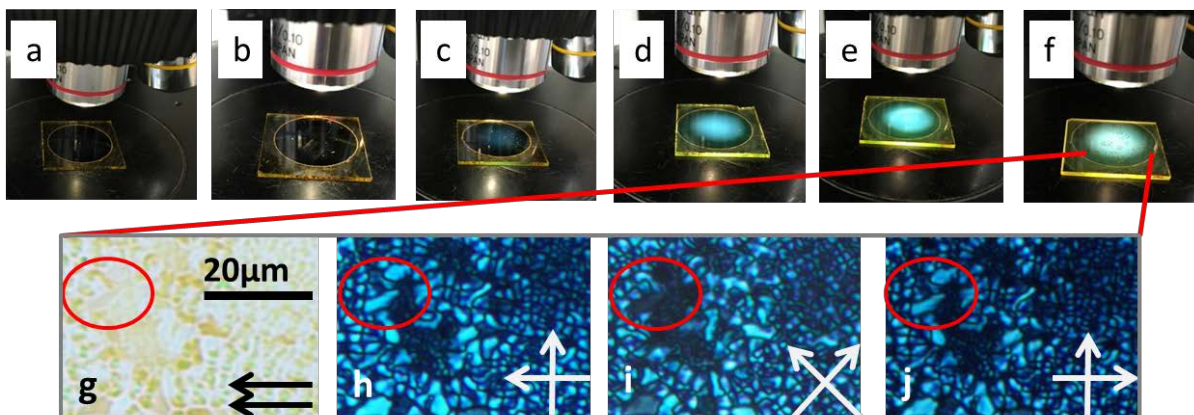


Figure 5. Macroscopic appearance of BY films spin-coated at varying humidity: (a) 27-30%, (b) 40-45%, (c) 46-50%, (d) 50-58%, (e) 52-59%, (f) 61-65%. Microscope images of BY film prepared under 61-65% RH: (g) between parallel polarizers; (h), (i), (j) between crossed polarizers but polarizer direction was rotated with respect to BY film.

When observed through microscope, the BY films that scatter light show more or less “sandy” textures (Figure 5g). The higher the humidity during the spin-coating process, the more obvious “sandy” texture can be seen. Taking the BY film prepared at higher humidity (61-65% RH) as an example, when observed between crossed polarizers while rotating the crossed polarizers, the bright domains of the “sandy” BY film become bright and dark alternately, as shown in the highlighted circle area of Figure 5h-5j. The observation confirms that the bright domains are crystalline grains.

It is our hypothesis that the crystalline grains are likely formed due to the water condensed from the humid air. Because of the fast evaporation of solvent during the spin-coating process, the temperature of spin-coated BY film surface could drop under the dew point of humid air and cause water condensation.^{11,15} The condensed water dissolves some of the BY which then form crystalline grains when the water evaporates. To check the hypothesis of water condensation, we utilized a cooling stage (mK 1000 series from INSTEC Inc.) to lower the temperature of an unexposed BY film (spin-coated at 25% RH) in humid air environment (60% RH). According to previous studies on the relationship between relative humidity and the dew point temperature in moist air,¹⁶ we cooled the temperature from 22 °C down to 10 °C to make sure water vapor condensed. After 3 min at 10 °C, the BY film substrate was moved from the low temperature to a bench (22 °C) for 5min, then heated on hot stage (100 °C) to dry. The absorption spectra and appearance of the BY film before and after water condensation are shown in Figure 6.

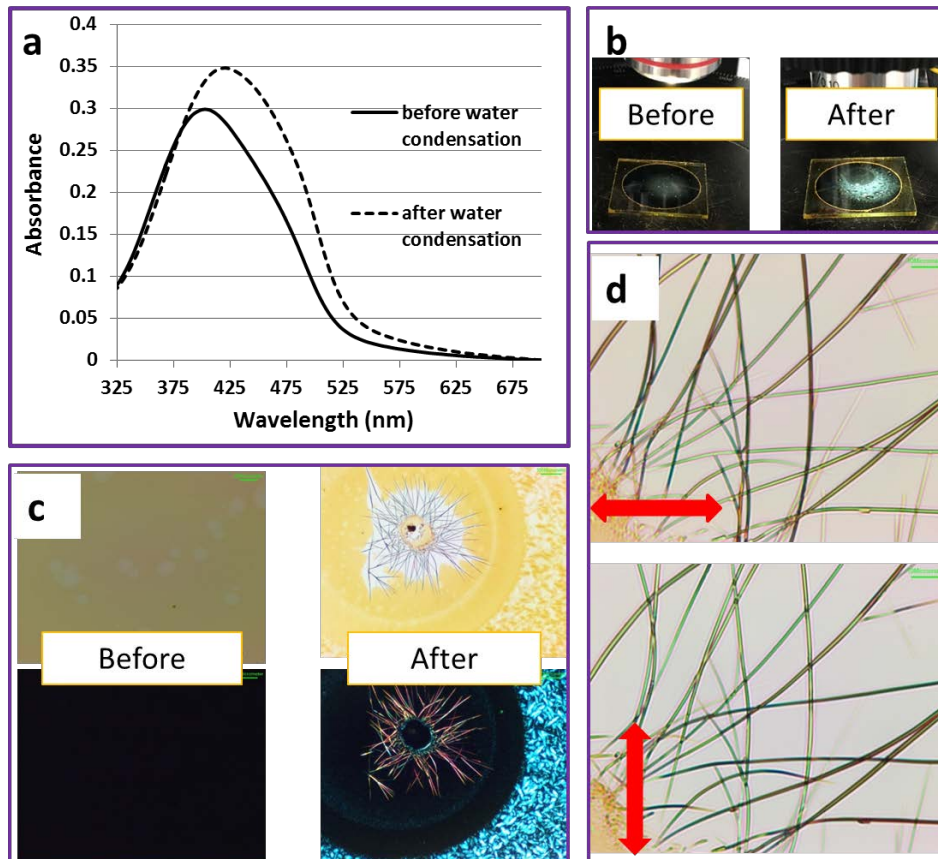


Figure 6. a) Absorption spectra of BY film before (solid line curve) and after (dash line curve) water condensation. b) Macroscopic appearance of BY film before and after water condensation. c) Microscopic images of BY film before and after water condensation. Top row: between parallel crossed polarizers; bottom row: between crossed polarizers. d) Fibrous BY crystals observed with polarized light (parallel and perpendicular polarization direction is indicated by the arrows).

After water condensation, the red shift of peak wavelength (Figure 6a), light scattering (Figure 6b) and crystalline grains (Figure 6c) were all observed. The one-dimensional fibrous crystals were also found in the BY film after the evaporation of condensed water. When observed through polarized light, these fibrous crystals parallel to the light polarization appear bright while the fibrous crystals aligned perpendicular to the light polarization appear dark, see Figure 6d. When the transition moment of the BY is parallel to the excitation polarization, the BY absorb light, appearing dark due to less light transmitted. When the transition moment of the BY is perpendicular to the excitation polarization, the BY does not absorb light, appearing bright. This alignment is consistent with the H aggregates¹⁷ where the BY molecules aggregate in a side-by-side way along the long axis of the fiber, similar to the well-known columnar phase of chromonic liquid crystals.¹⁸

3.1.2 Effect of humidity at stage I (substrate storage) and at stage III (unexposed BY film storage)

We also investigated the effect of humidity present during storage of cleaned substrates before coating and BY films after the spin coating process but before exposure. As can be seen from Table 1, the water

absorbed by glass plates does not affect the photoalignment of BY since the BY films spin-coated on glass plates sitting at both high humidity and low humidity have similar high order parameters.

Table 1. Order parameters of BY films prepared on glass substrates stored at different humidity for different lengths of time before spin-coating.

Storing condition and time	2.5 hours	22 hours	48 hours
Substrate kept at high humidity (80-90% RH)	0.85	0.82	0.86
Substrate kept at low humidity (<16% RH)	0.81	0.86	0.84

Table 2. Order parameters of BY films stored at different humidity for different lengths of time before polarized light exposure.

Storing condition and time	2.5 hours	22 hours	48 hours
BY film kept at high humidity (80-90% RH)	0.11	0.04	0.01
BY film kept at moderate humidity (40-45% RH)	0.77	0.76	0.79
BY film kept at low humidity (<16% RH)	0.82	0.78	0.61

Considering the effect of humidity after the film coating but before exposure, we saw a more significant effect. After sitting at different levels of humidity for a specific time, the unexposed BY films were photoaligned with the same polarized light exposure (25mW/cm², 5min). As shown in Table 2, the BY film sitting at moderate humidity (40-45%) show relative constant order parameters even after 48-hour sitting. The BY films sitting at high humidity (80-90% RH) show a dramatic change of order parameter after sitting for 2.5h and almost no alignment (order parameter decreased to 0.01) occurring with longer (48h) sitting. Besides the low order parameter, we also noticed that these unexposed BY films scattered light and showed crystalline grains under microscope after sitting in a sealed box containing water for 2.5h or longer. All these observations indicate the humidity absorbed by unexposed BY film has a significant effect on its photoalignment. The BY films sitting at low humidity (< 16% RH) also showed a decreasing trend of order parameter with increasing sitting time, but in this case no light scattering or indication of crystallinity was observed.

3.1.3 Effect of humidity at stage IV (aligned BY film storage)

With order parameters listed in Table 2, sitting at either high humidity or low humidity results in the decrease of order parameter. In other words, the annealing process stabilizes the BY and prevents the BY from being aligned by polarized light. Based on this thought, we conducted some experiments to determine the effects of humidity and dry annealing on aligned BY films. We first prepared two BY films under low humidity (25% RH), exposed the film to polarized blue light at 25mW/cm² for 5min, measured

the absorption spectra and calculated order parameters, then kept one aligned BY film in a sealed box containing water (80-90% RH) and another in a sealed box containing desiccant (<16% RH). The sitting time dependence of order parameters of these two BY films is plotted in Figure 7.

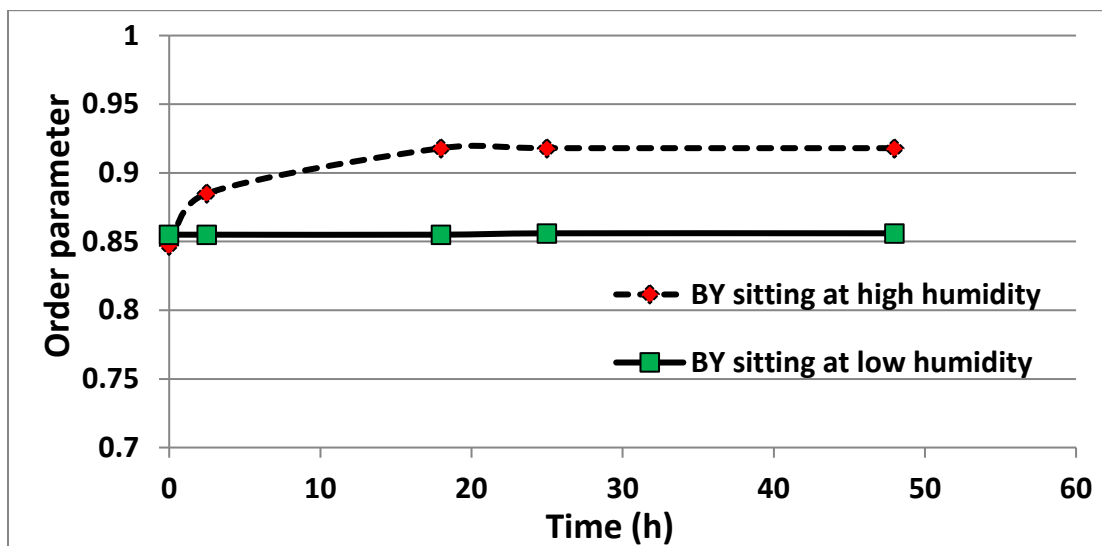


Figure 7. Time dependence of order parameters of one BY film sitting at high humidity and one BY film sitting at low humidity.

As can be seen from Figure 7, the order parameter increased to 0.92 after sitting at high humidity (in a box containing water, 80-90% RH) for 18h, while almost no change was observed for the BY sitting in a dry environment (<16% RH) for 48h. This may be due to absorbed water vapor increasing the order of aggregates of BY molecules.¹³ However, even after sitting at high humidity for 48h, the aligned BY film still appears clear, no obvious light scattering or crystalline grains was observed.

To further investigate the effect of humidity annealing on alignment stability, we compared three aligned BY films – one with humidity annealing (aligned then sitting in a water-box for 48h), one with dry annealing (aligned then sitting in a desiccant-box for 48h) and one aligned then immediately processed with stabilizing test. After every stabilizing test, the absorption spectra were measured when the polarized direction of the incident light for spectroscopy was 0°, 45°, 90°, 135° to that of original incident polarized blue light for photoalignment. For these three tested BY films, the re-writing exposure time dependence of absorbance maximum values measured in each direction was plotted in Figure 8. With increasing stability test (re-writing) exposure time, for all these tested BY films, absorbance maximum decreased when measured at directions of 45° and 90° while increased when measured at directions of 0° and 135°.

Compared with BY films without sitting and with humidity annealing, after 65min re-writing exposure, the BY film with dry annealing shows the largest peak absorbance value measured at direction of 90° and the smallest peak absorbance value measured at direction of 0°, indicating a better stability of original photoalignment. A possible interpretation of these results is that annealing in a high humidity allows the order of the aggregated BY molecules to increase as observed by Matsumori. *et al*¹³; while

annealing in the dry environment may remove some water in the film, and thus decrease the mobility of BY molecules, making them more difficult to re-align during the second photoalignment process.

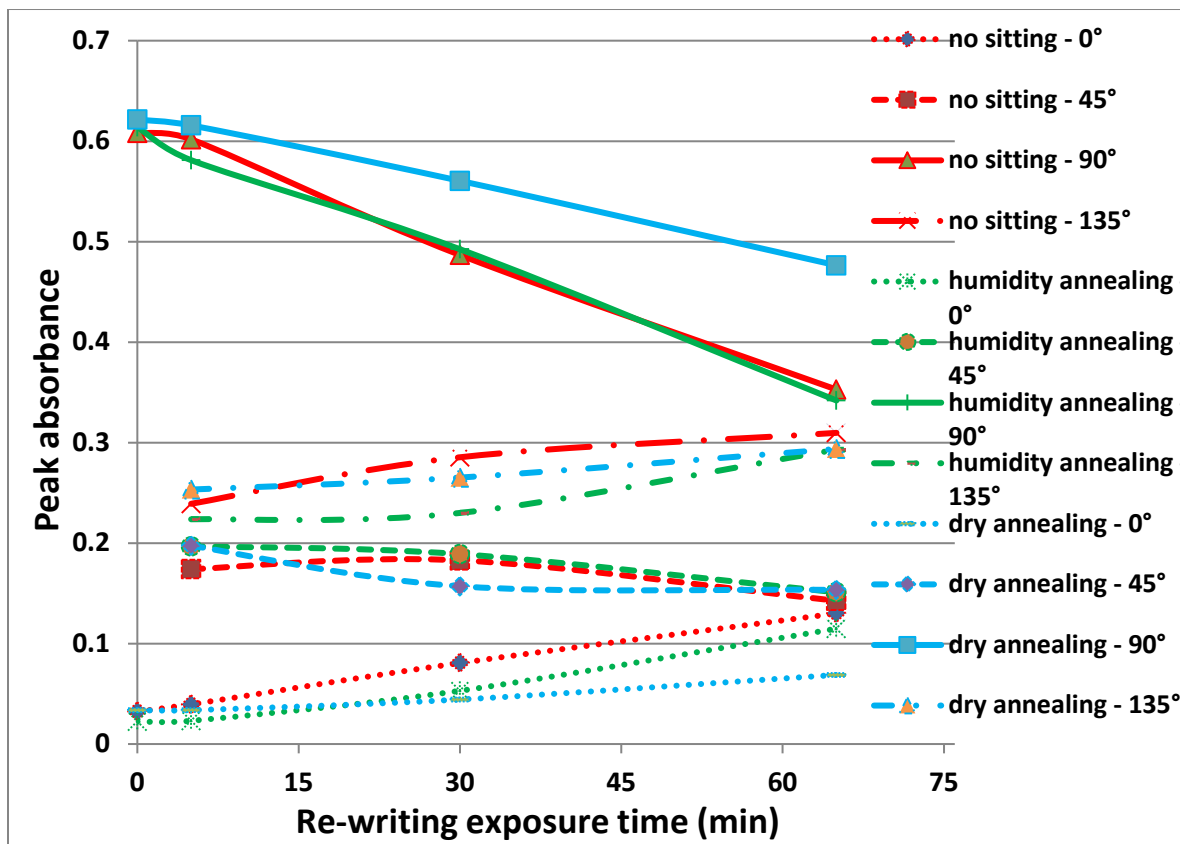


Figure 8. Stabilizing tests results of three aligned BY films processed without sitting, with humidity annealing and with dry annealing, respectively: re-writing exposure time dependence of peak absorbance values measured when the polarized direction of the incident light for spectroscopy was 0°, 45°, 90°, 135° to that of original incident polarized blue light for photoalignment.

3.2 Effect of surface types

We also studied the photoalignment of BY when it was deposited onto different surfaces. Here, we studied four surfaces: ITO glass, glass, PVA film, polyimide film. Under humidity of 35-40% RH, two BY-DMF solutions with different concentrations (0.1 wt. % or 1.5 wt. %) were spin-coated onto these different surfaces to create thin and thick BY films. Compared with the absorbance values of a BY-DMF solution (0.001%) in a quartz cuvet and the unexposed BY films, and according to Beer's Law, we estimate the resulting thin BY film thickness around 3nm when spin-coated with 0.1 wt. % solution and the thick BY film around 30nm when spin-coated with 1.5 wt. % solution. These absorption spectra of thick BY films and thin BY films before and after polarized light exposure (25mW/cm² for 5min) were measured and their order parameters based on the spectra were calculated as 0.77, 0.80, 0.79, 0.77 for thick film (from 1.5% solution) on ITO glass, bare glass, PVA film and PI2555 film, respectively; and 0.66, 0.81, 0.25, 0.55 for thin film (from 0.1% solution) on ITO glass, bare glass, PVA film and PI2555 film,

respectively. To clearly compare the effect of PVA surface on thin and thick BY films, all the original absorbance values from thin film before and after exposure were multiplied by 15, as shown in Figure 9. For the thick film, the surface does not affect its order parameter; for the thin film, the BY on PVA film shows a relatively small order parameter (0.25), maybe due to the stronger hydrogen bonding between BY molecules and hydroxide groups of PVA film¹². All these results indicate that the surface has some influence on the photoalignment of thin BY film; but for the thick BY film, the surface effect can be neglected.

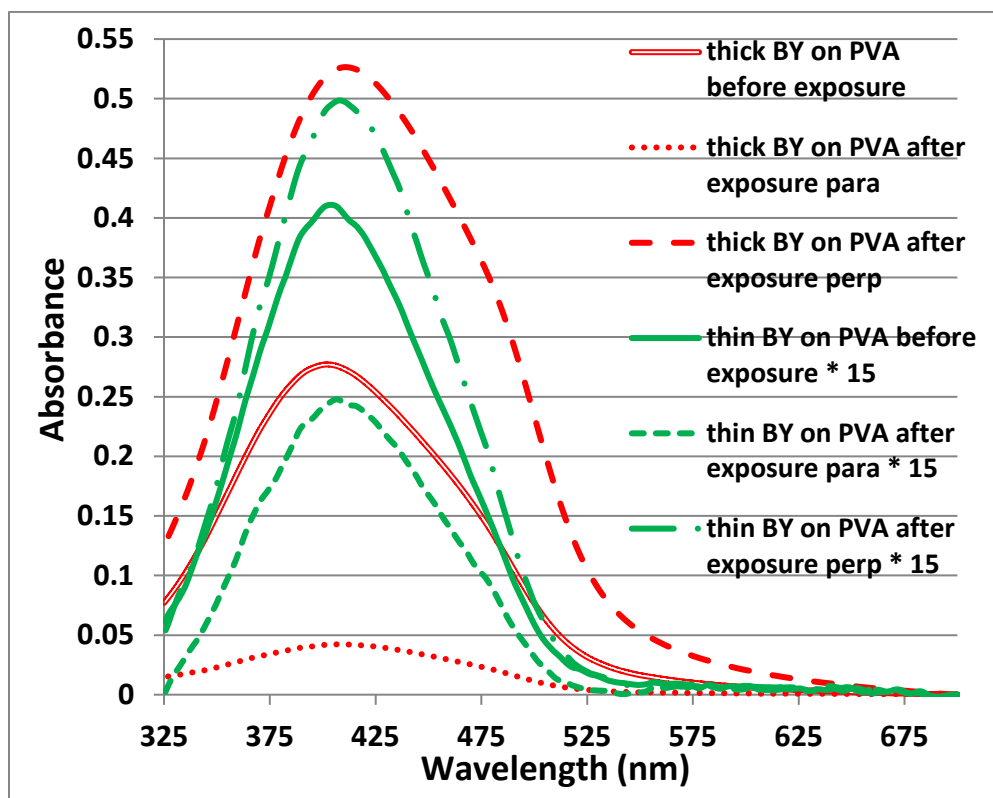


Figure 9. Absorption spectra of thick BY films (from 1.5 wt. % solution) and thin BY films (from 0.1 wt. % solution) spin-coated (1500rpm, 30s) on PVA film. The absorption spectra of thin BY film shown here was the modified original absorbance values multiplied by 15.

4. Discussion

Looking at the combined results above, we can see some trends. One is that, if a BY film is kept in a very low humidity environment (< 16% RH), it becomes more difficult to photoalign the BY molecules (or to realign them with a second exposure) , and no effect of macroscopic crystallinity is observed. On the other hand, if the humidity is high (80-90% RH), before photoalignment, obvious micro-crystalline domains are observed and cause the films to be more difficult or impossible to subsequently photoalign. But surprisingly, high humidity applied to an aligned film causes its order to increase and does not cause apparent crystallinity.

Noting the different effects of high humidity on BY before and after exposure, and the similar results on BY films from spin-coated at high humidity (>60% RH) and processed with water condensation, and further the observation that the formed fibrous crystal structure is a stacked molecular structure (rather than an end to end structure), it can therefore be considered that after the BY film is photoaligned, it may be difficult for the layer to form its preferred crystal structure, and a high degree of crystallization is not observed, but aggregation as seen in reference 10 may be occurring. This hypothesis is bolstered by the observation that the stability of aligned film to a second re-writing exposure of light is not increased by the annealing in a high humidity environment.

On the other hand, the stabilizing tests show the aligned BY film with dry annealing shows better stabilization than the BY with humidity annealing. This is consistent with the mobility of BY molecules being affected by the presence of water.

Related to the effect of substrate type used for the BY layers: thin BY films (3nm thickness) coated on a PVA surface had a lowered order parameter. It might be considered here that the hydroxide (-OH) group in the PVA surface forms stronger hydrogen bond with BY¹² and therefore make the BY difficult to re-orient. We also notice that thick BY film (30nm thickness) on PVA surface shows an order parameter more typically seen with other substrates tested, indicating BY molecules in the bulk are not affected by the hydrogen bond from the surface.

5. Summary

The ability to photoalign the azo-dye Brilliant Yellow (BY) is shown to be strongly dependent on exposure to humidity, but only weakly dependent on the surface on which it is coated. It is seen that the effect of high humidity applied to the BY layer before light exposure degrades the quality of the subsequently exposed layer, while the application of high humidity after exposure increases its order. However, very low humidity during storage of the BY films appears to lower the mobility of the BY molecules to make photoalignment (or realignment) more difficult. It is hoped that the results of this paper allow for the optimization of the photoalignment of BY as well a better understanding of the BY photoalignment mechanism.

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