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The Study of Transmission Spectrum of Twisted Nematic Liquid Crystal Doped with Phosphorus Micro Particles Apply for Vehicle Lamp

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Abstract

In this study, the spectrum changes induced from the doping of phosphor micro particles in a twist nematic liquid crystal cell was observed. The experimental results show that the achromatic transmission can be observed with a proper driving condition, which may be applied to the design of an achromatic liquid crystal device. In this paper, we tried to figure out the spectrum changes induced from the doping of phosphor micro particles. The experimental result of the phosphor powder doped twist nematic liquid crystal cell shows that the achromatic transmission and the wavelength linearly dependent transmission both can be observed with some proper driving conditions, respectively. The result is useful on developing an achromatic liquid crystal device and it can be applied for Vihicle lamp.

Keywords: *Twist Nematic Liquid Crystal, Phosphor Micro Particle, Spectrum.*

1. Introduction

Liquid crystal materials have been applied in many optical systems and instruments. Owing to the capability of phase retardation control, liquid crystal based variable retarder is used to the manipulation of polarization, phase, or intensity of a beam [1]. Among which, many efforts have been made to the development of achromatic liquid crystal devices [2],[3],[4]. The method to construct an achromatic liquid crystal device mainly use the combination of several liquid crystal cells with different orientations [5]. Since the wavelength dependence of transmission of a liquid crystal cell is an intrinsic property, changing the material properties of liquid crystals will introduce a different feature into the transmission spectrum [6],[7],[8]

In this paper, we tried to figure out the spectrum changes induced from the doping of phosphor micro particles [9-11]. The experimental result of the phosphor powder doped twist nematic liquid crystal cell shows that the achromatic transmission and the wavelength linearly dependent transmission both can be observed with some proper driving conditions, respectively [12],[13]. The result implies that the phosphor doping method may be applied to the achromatic liquid crystal device [14],[15]

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2. Experiment

The twist nematic liquid crystal is one of the most conventional liquid crystal cell types. We used the twist nematic liquid crystal cell to observe the changes of transmission spectrum induced from phosphor micro particle dopant. All the sample were prepared in our lab. The alignment layer of the cell was processed by our home-made rubbing machine. The substrates were assembly with a crossed aligned direction to form a twist liquid crystal cell. The cell gap was controlled at about 16 m. The liquid crystal we used is DLC-11121 (from DAXiN). The nematic to isotropic phase transform temperature is 76.05°C, and the optical anisotropy Δn is 0.12430. The phosphor powder we used shows color of orange-yellow, and the average particle diameter is about 7μm. The doping concentration of phosphor powder is 1% (weight concentration). After doping the phosphor powder into the liquid crystal, the mixture was treated with a 45-minute of ultrasonic oscillation at temperature about 10~12°C, and then a 45-minute of magnetic stirring. After the phosphor powder has been homogeneously separated in the liquid crystal, the mixture was immediately filled into the empty cell, and then the following preparation process was completed.

In short, we named the pure nematic liquid crystal cell as LC and the phosphor doped liquid crystal cell as PH in the following discussion. The appearance of LC and PH samples were checked by inserting the cells into a pair of cross polarizers. Fig. 1 shows the pictures of LC and PH, in which the rubbing direction of the first substrate is parallel to the polarizer, and that of the second substrate is parallel to the analyzer. As shown in the picture, the color and brightness of both samples are quite similar, suggesting that the cell still possess the homogeneous domain after doping phosphor powder.

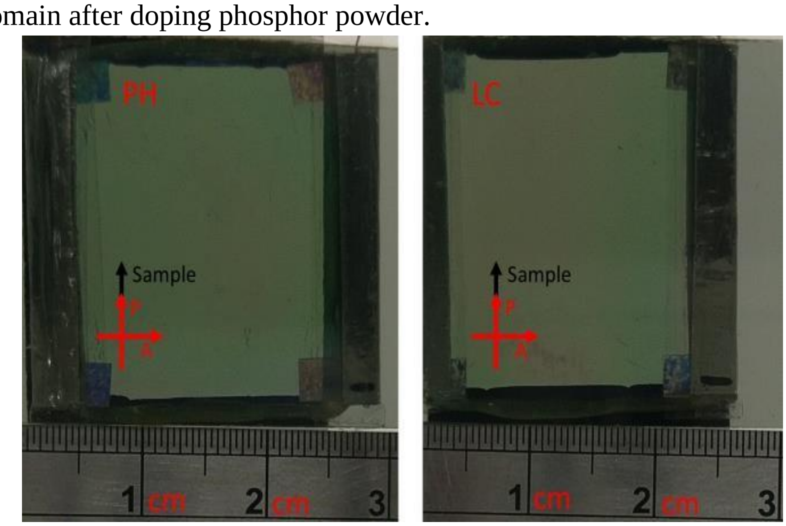

Figure 1. Sample appearance with a pair of cross polarizers.

To characterize the transmission property of LC and PH, the samples were observed by using a spectrometer (Perkin Elmer Lambda 900). We measured the transmission spectrums of the liquid crystal cell with several driving voltages and put the sample between a pair of cross polarizers. The AC voltage was applied with a 1KHz square wave from a function generator. The voltage amplitude ranged from 0~10V, with an interval of 0.5V. The spectrums were taken in the visible range, from 350~700nm.

3. Results

Fig. 2 shows the spectrum of LC and PH taken at 0~2.5V. The spectrums from 0 to 2.5V are all overlapped, so the liquid crystal molecules in LC and PH are not driven in this voltage range. Comparing the spectrums, at wavelength below 450nm, LC and PH show the same transmission. In ranges of 500~550nm and 600~689nm, the transmission of LC is higher than that of PH, but in 552~594nm, the transmission of PH is larger than that of LC.

The spectrums shown in Fig. 3 are corresponding to 3V and 3.5V. The curves are quite different from those in Fig. 2, since the liquid crystal molecules are oriented at these applied voltage. The initial voltages of LC and PH seem to be both around 3V. The curve also becomes smoother, compared to that in Fig. 2. The transmission of the PH sample driven by 3.5V is almost linear dependent to the wavelength at the range of 550~700nm, while the LC sample shows a nonlinear wavelength dependence

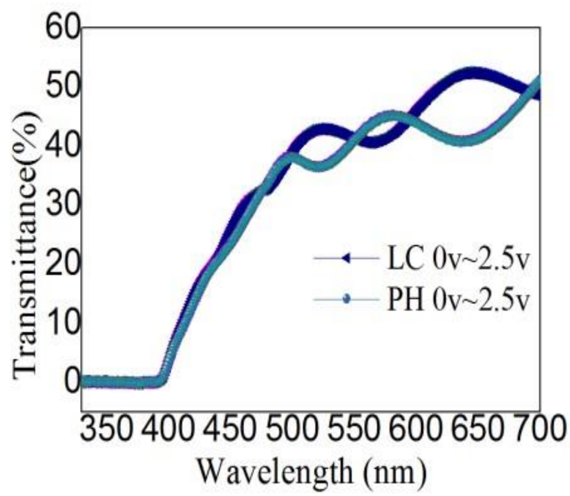

Figure 2. Spectrums of LC and PH, applying voltage 0~2.5V.

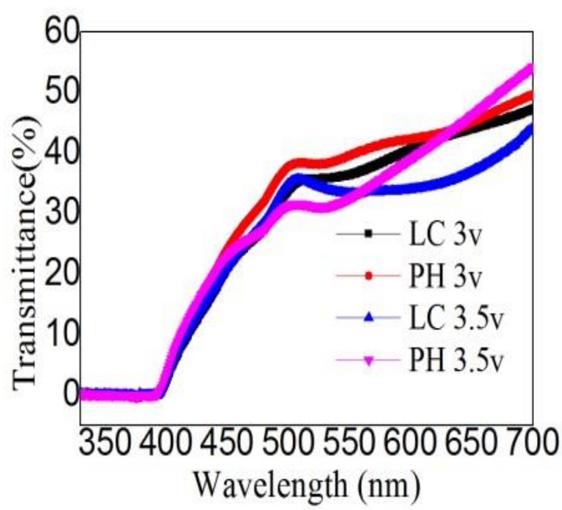

Figure 3. Spectrums of LC and PH, applying voltage 3 and 3.5V.

Spectrums shown in Fig. 4 are corresponding to LC applying 5V and 7V, and PH applying 5V and 6.5V. The curves of 5V of LC and PH in the range of 550~700μm both show wavelength independent behaviors, but the transmission of PH is lower than that of LC. As shown in the figure, the spectrums of LC at 7V is overlapped with that of PH at 6.5 V, implying that the driving voltage of the phosphor powder doped sample is lower than that of pure liquid crystal, about 0.5V.

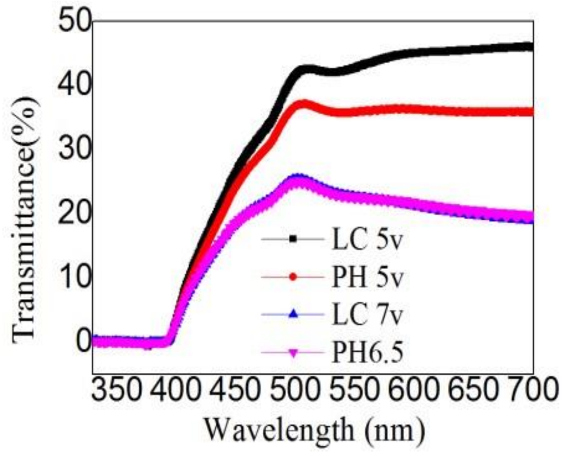

Figure 4. Spectrums of LC and PH, applying voltage 5~7V

4. Conclusion

In this paper, we observed the spectrum changes induced from the doping of phosphor powder of a twist nematic liquid crystal cell. The spectrums show that the wavelength independent and wavelength linearly dependent transmissions both can be observed with some proper driving conditions, respectively. This result is useful on developing an achromatic liquid crystal device. In this study, we tried to figure out the spectrum changes induced from the doping of phosphor micro particles. The experimental result of the phosphor powder doped twist nematic liquid crystal cell shows that the achromatic transmission and the wavelength linearly dependent transmission both can be observed with some proper driving conditions, respectively. The result implies that the phosphor doping method may be applied to the achromatic liquid crystal device,

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