

## The Investigation of High-Luminance Complex Colorant for LCD Color filter

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### ABSTRACT

Each Color is one of the most important properties of vision. Pigment and dye are the most popularly used color filters, which are based on the material selective absorption in the visible band. Various pigments or dyes have to be integrated together by multistep processing to realize a colorful image. Conventional color filters used in LCD system consist of dyed material, which generates visible colors by transmitting the desired bandwidth of light and absorbing the undesired spectra. In this review, we will discuss the mechanisms of various structural color filtering techniques for both reflective and transmittive color filters and then focus on the integrated applications of structural color in the fields of imaging, display.

**KEYWORDS:** Pigment, Dye, LCD color filter

### INTRODUCTION

Diketopyrrolopyrrole (DPP) and their derivatives have a high performance red colorant due to their excellent thermal or light stability with brilliant color shades. Especially, DPP derivatives such as diphenyl-diketopyrrolopyrrole have melting point of over 350 °C, an absorption in the visible region, a strong photoluminescence with a maximum of between 500 nm and 600 nm. The structure analyses of diphenyl-diketopyrrolopyrrole pointed out that the phenyl rings are twisted out of the heterocyclic plane. The intermolecular hydrogen bonding between neighboring the lactam NH and carbonyl units dominates the structure of DPP. We presented a new class of pH-sensitive indicator dyes based on diketopyrrolopyrroles. DPPs are usually insoluble in organic solvents and are used mainly as ink or print pigments and laser dyes in solid state. Also, the soluble DPP derivatives are applied in photovoltaics and fluorescent probes. In now, the new DPP based pH indicators were shown to be highly promising for application in optical pH and carbon dioxide sensors.



*Fig. 1 : DPP modified structures and compounds*

### THEORY

LCD is composed of two main parts: a color filter and a thin film transistor circuit board. In the image processing of LCD device, the role of the color filter is the most important in terms of the color properties that can be classified into three categories: color purity (color strength and color representation), contrast ratio, and brightness. The color filter consists of red, green, and blue color pixels that are prepared by coating a photo

resist that contains polymeric binder and pigments. The grade of HDTV generally requires a highly functional color filter with color purity of around 72%, while mobile and monitor grades need color filters with color purity of around 45% and 60%, respectively, based on the NTSC standard, shown in Fig 2. Red, green, and blue, three primary colors for color filters, are produced by the various pigments. A suitable selection of pigment is significant to make the color filter show excellent color purity, brightness, and contrast ratio. Higher concentration and mixture ratio of pigment are required to get higher color purity, but brightness is in inverse proportion to the concentration. The introduction of pigment had overcome the drawbacks of dyes,

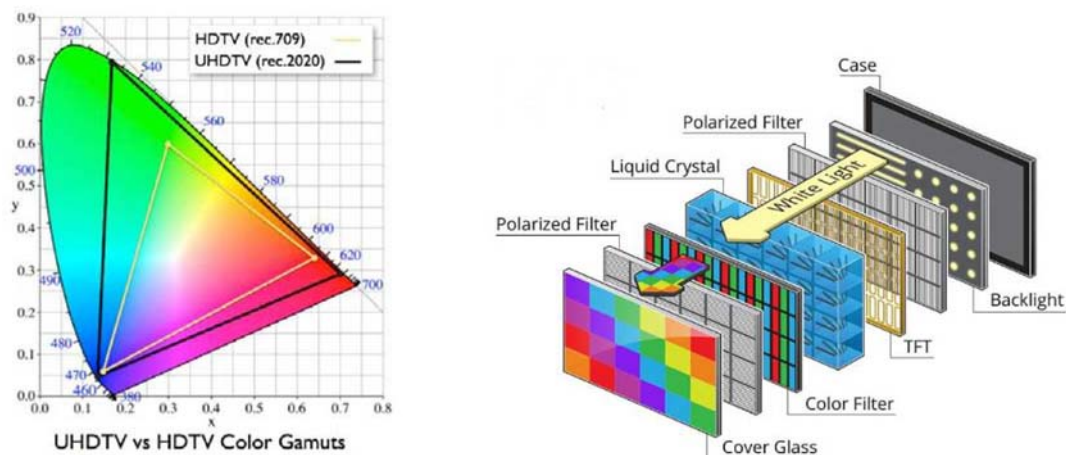
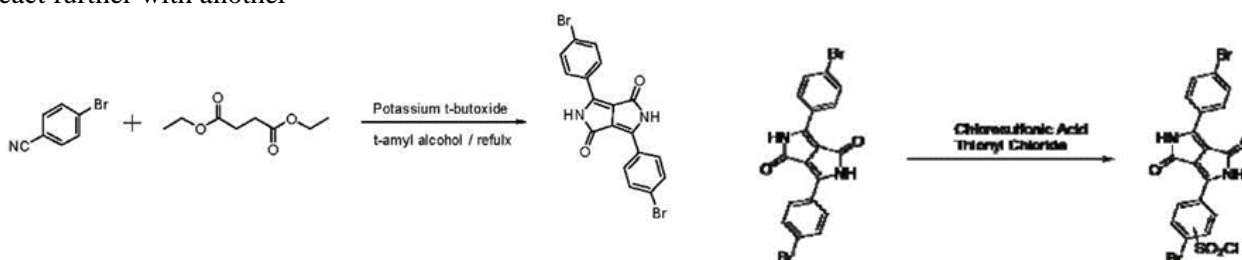


Fig. 2 : CIE 1931 chromaticity diagram and typical color filter of LCD devices.

Color purity can be assessed by CIE Yxy chromaticity. The Y value is brightness, while the x and y values are color coordinates on the CIE 1931 color chromaticity diagram. The percent value of color purity as a triangle area can be calculated based on the NTSC standard; the bigger triangle implies higher color purity as shown in Fig 2.

## EXPERIMENTAL

There are several reports for the synthesis of DPP pigments. The succinic ester route is regarded as the best one. In this route, the succinic ester is condensed in a pseudo-Stobbe condensation with an aromatic nitrile in the presence of strong base to afford the desired DPP in a yield over 60% (Scheme 2). The key-step of the mechanism is the formation of pyrrolinone esters from the initially formed enamino-esters; then it can react further with another



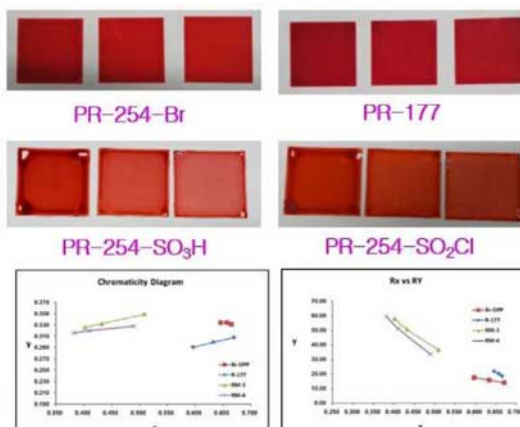
Scheme 1: Synthetic route of DPP.

## RESULTS AND DISCUSSION

CI Pigment Red 254 was used as a main color for preparation of red pixel. The red pigment can be used alone or together with CI Pigment Red 177. The maximum transmittance observed around 650 nm for CI Pigment Red 254 and 670 nm for CI Pigment Red 177. CI Pigment Red 177 produced deep red color, while CI Pigment Red 254 produced bright red color. For this reason, the combinations of these red pigments are needed for the appropriate target value. As previously discussed, type and mixture ratio of pigments are essential to achieve better color purity of the color filter of LCD.

Table 1. The evaluation of color differences (CIE Lab) of PR 254 and their color properties.

SID		L*	a*	b*	C*	h	
PR-254-Br	D65/10	62.7	2.9	5.7	6.4	63.1	
	A/10	63.5	5.3	6.2	8.2	49.3	
	F11/10	63.1	3.4	5.8	6.7	59.2	
SAMPLE		$\Delta E^*$	$\Delta L^*$	$\Delta a^*$	$\Delta b^*$	$\Delta C^*$	$\Delta H^*$
PR-254-Br	D65/10	3.18	-0.74	-2.80	-1.28	-1.98	2.36
	A/10	4.31	-1.15	-3.65	-1.98	-3.63	2.02
	F11/10	3.25	-0.88	-2.70	-1.57	-2.45	1.94
PR-254-Br-SO <sub>3</sub> H	D65/10	2.57	-0.55	-2.24	-1.14	-1.18	1.77
	A/10	3.59	-0.89	-3.04	-1.69	-3.12	1.55
	F11/10	2.85	-0.66	-2.15	-1.39	-2.15	1.39
PR-254-Br-SO <sub>2</sub> Cl	D65/10	2.47	-0.19	-2.27	-0.95	-1.60	1.87
	A/10	3.45	-0.52	-3.05	-1.51	-3.00	1.88
	F11/10	2.48	-0.30	-2.16	-1.17	-1.94	1.51



The typical spectrum of CCFL shows that the central peak value of each color, red, green, and blue is around 611 nm, 544 nm, and 440 nm respectively. The amplitude width and central peak values are unalterable in the case of using typical phosphors; however, the degree of lighting intensity can be controlled by adjusting the proportion of R, G, and B phosphors.



Fig. 3 : A light-fastness and solvent resistance test of DPP pigment

### CONCLUSION

It was found that CI Pigment Red 254 and CI Pigment Red 177 were useful for main colors. We found also that the improvement of color purity could be achieved by concentration and mixture ratio of pigments. This study showed that appropriate combination of the pigments produced color purity greater than 72% suitable for HDTV, an electronic device, which preferentially uses color purity instead of brightness. For mobiles and notebook PCs, color purity could be achieved at around 44% without decrease of brightness. As the results of these experiments, increase of color purity gives rise to decrease of brightness; we have to solve this problem with an introduction of new kinds of pigments or dyes, which give better color purity and brightness simultaneously

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Park, S. *et al.* THE INVESTIGATION OF HIGH-LUMINANCE COMPLEX FOR LCD COLOR  
FILTER

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