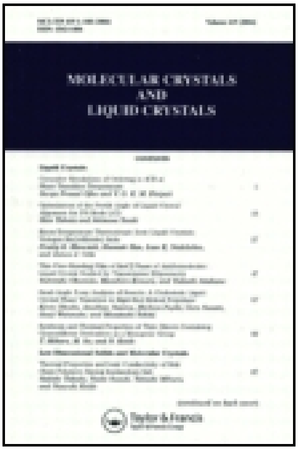

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Stability Studies on Polymer Dispersed Liquid Crystal Films

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STABILITY STUDIES ON POLYMER DISPERSED LIQUID CRYSTAL FILMS

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Abstract Polymer Dispersed Liquid Crystal(PDLC) is a class of electroscattering materials exhibiting very promising properties for display device applications. For the last few years, the electrooptical properties of PDLC have improved drastically to use projection device with high brightness. We have studied stability of PDLC films which formed by ultraviolet initiated photopolymerization and liquid crystal phase separation. We evaluated several stability items in PDLC films such as running and environment test, accelerated life time at low and elevated temperature, voltage holding ratio(VHR) variations according to UV exposing time and temperature.

INTRODUCTION

Recently PDLC films which consist of micron-sized nematic liquid crystal droplets dispersed in a polymer matrix[1] have attracted great attention, since they have a lot of advantages, such as operating without polarizers and easy fabrication of large area display devices.[1,2] We have studied stability factors of PDLC films which had been formed by ultraviolet initiated photopolymerization and liquid crystal phase separation. For each of tests we used well characterized PDLC test cells shown previously.[3] The reliability has been improved by optimising PDLC structure and synthetic conditions. For the higher electrooptical stability of the PDLC films, halogenated liquid crystals are used. A major objective of these stability studies was to identify PDLC films which are acceptable for use in projection displays. We evaluated several stability specifications in PDLC films such as running and extended storage in low temperature, a combined high humidity and high temperature environment, thermal shock, voltage holding ratio(VHR) variations according to UV exposing time.

EXPERIMENTAL PREPARATION AND MEASUREMENT

All PDLC samples were formed from isotropic solutions of UV curable monomers/ oligomers and liquid crystal mixtures. The homogeneous mixture was placed between two glass slides containing a transparent conductive layer such as indium-tin-oxide separated by 10μm thick micropearl spacer. This mixture was then exposed to UV irradiation from a 20W mercury lamp, yielding intensity at the cell surface of about 10mW/cm^2 at 365nm. To protect from moisture and air barrier, all tested samples are sealed with epoxy resin which is incompatible to PDLC films. Various liquid crystal compositions were evaluated in PDLC films to correlate their chemical structure to their long term stability. Electrooptical properties of the PDLC films were evaluated on the optical bench set up previously described.[4] The VHR ratio can be determined by simultaneous monitoring of the rms values of the driving voltage applied to the

TFT and the actual voltage at the electrodes of the picture element.[5] We have determined this characteristic VHR, with a set up developed recently, shown in Figure 1.

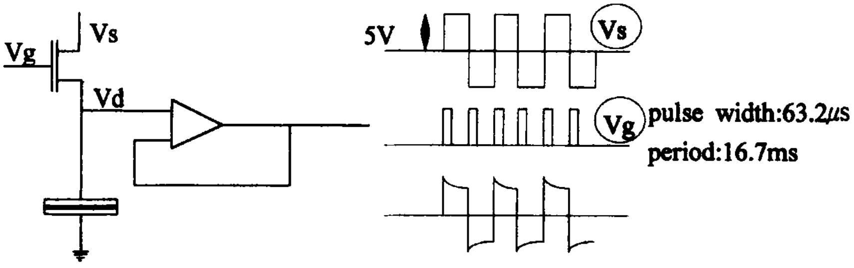

FIGURE 1 The measurement scheme of VHR.

RESULTS & DISCUSSION

The running tests were divided into two items: study aimed to pass the continuous running, and directed toward durability of on/off operation repeatedly. The applied voltage, frequency and testing time of these tests was 9Vrms, 60Hz, and 2,000hr respectively. The interval of on/off switching time was 1sec. We have evaluated PDLC samples per 100hr to detect changes in the driving voltage, response time, contrast, hysteresis and VHR. As the result of running tests, there is no change of electrooptical properties and VHRs, consequently we understood PDLC films are reliable on continuous running and on/off operation. Low temperature stability tests were carried out in a freezer at -40℃ for 500hr. Many PDLC films obtained with the storage showed little change in electrooptical properties and VHRs, as seen in TableⅠ.

TABLE Ⅰ Storage stability of PDLC at -40℃.

Hr	Vop (Vrms)	Response time (ms)	Contrast	Hysteresis (ΔV)	VHR (%)
0	6.0	28	128	0.09	80
100	6.0	31	210	0.16	83
200	6.0	26	165	0.16	82
300	6.0	28	197	0.12	84
400	5.8	25	169	0.15	85
500	6.0	25	144	0.12	82

Elevated temperature and high humidity storage tests were completed in a system 60 ℃ and 90%RH for 500hr. Almost all the electrooptical properties showed little change, including contrast, summarized in TableⅡ. Thermal shock stability is tested 20 cycles as follows: -40℃×60min → rt. 5min → 85℃×60min → rt. 5min. No changes of electrooptical properties and VHR have occurred after test. The effect of UV exposure was tested with 3.0mW/㎠ intensity at 365nm for 1000hr. The photostability of PDLC film is related to chemical structure of polymer and liquid crystal,[3] greatly affected liquid crystal substituents. Our PDLC films have a little cyano substituted liquid crystals(about 10wt% in LC mixture) for improving electrooptical properties. It is well known that fluoro substituted liquid crystal has higher VHR value than cyano substituted,[5] this is well coincided with our results, shown in Figure 2. However the electrooptical properties did not change after long term UV exposure, summarized in TableIII.

TABLE II Storage stability of PDLC at 60℃ with 90%RH.

Hr	Vop (Vrms)	Response time (ms)	Contrast	Hysteresis (ΔV)	VHR (%)
0	6.0	24	200	0.16	82
100	6.5	24	186	0.16	80
200	6.6	22	200	0.24	79
300	6.3	22	158	0.23	81
400	6.3	21	152	0.23	81
500	6.0	22	128	0.20	77

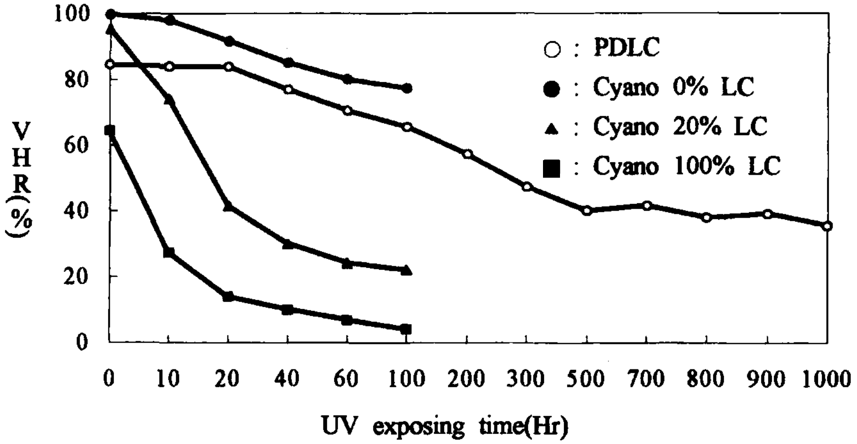

FIGURE 2 The VHR variations according to UV exposing time.

TABLE III The electrooptical property variations according to UV exposing time.

Hr	Vop (Vrms)	Response time (ms)	Contrast	Hysteresis (ΔV)	VHR (%)
0	5.8	27	114	0.12	85
100	5.5	26	102	0.11	76
300	5.8	25	105	0.10	59
500	5.5	29	102	0.11	48
700	5.5	29	131	0.13	52
1000	5.5	27	118	0.12	43

The VHR of PDLC is decreased when the temperature is increased because of enhancing PDLC film mobility, demonstrated in Figure 3. The variations of electrooptical properties are shown in our previous publication[6] when the temperature is increased.

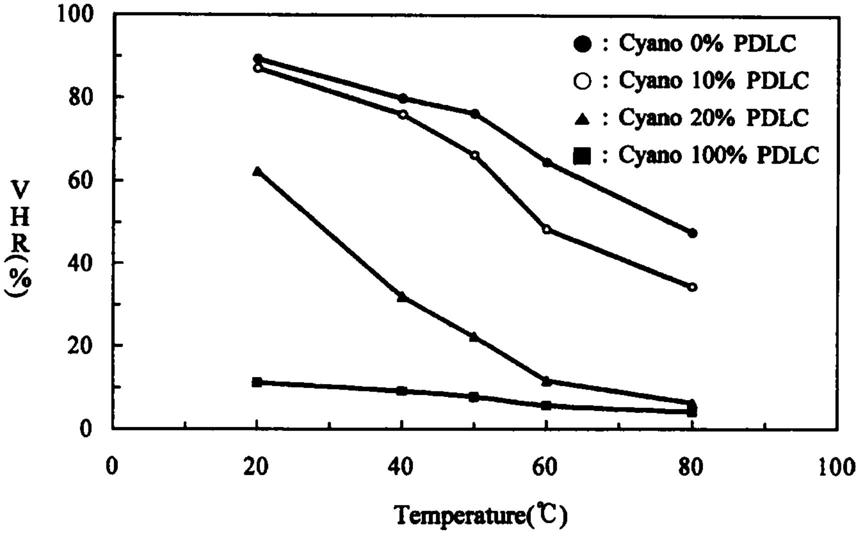

FIGURE 3 The VHR variations according to temperature.

CONCLUSION

We have studied stability of PDLC films for use in projection displays. The running and environmental test(low temp., high temp. and humidity, thermal shock) showed little change in electrooptical properties and VHR, but it is very difficult to keep VHR without deterioration when cyano substituted PDLC films are exposed UV, even though cyano amount is very small. This shows the same results when PDLC films are in elevated temperature. Our PDLC film has good stability for electrooptical property and VHR in running and environmental tests but not good enough stability for VHR in accelerated life time test. Consequently when PDLC is formed for using in TFT, cyano substituted liquid crystal should not be used because PDLC having low VHR may occur low brightness in TFT PDLC panel. We will apply this TFT PDLC panel to front type projector and the result will be discussed later.

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