

Study the effects of epoxy/tri functional mercaptan resins structure based PDLC films

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Abstract. The present investigation is focused on to find out the effects of the structure of epoxy/tri functional mercaptan resins based polymer dispersed liquid crystal (PDLC) films on the morphology of polymer matrix via heat curing system. The interaction between epoxy reaction and polythiol group (-SH) resins turn played an essential role in step-growth polymerization reaction for the preparation of PDLC films. In addition to this, the polymer morphologies in this heat curing system have been regulated from polymer beads to porous polymer matrix by changing the liquid crystals (LCs) contents, chemical structures of epoxy tri functional mercaptan resins, and functionality of thiol hardeners. On the other hand, the thiol group (-SH) fractured the PDLC films continuously with changing driving voltage radically. With the enhancing content of the epoxy resins, the LC domain size decreased, while the thiol had a various effect on the LC domain size. It was of great importance for the optimisation and the possible applications of the PDLC films.

Keywords. epoxy/tri, mercaptan resins, PDLC films

1. Introduction

Polymer dispersed liquid crystal (PDLC) are a kind of functional macro molecular composite, that consist of haphazardly dispersed liquid crystal (LC) domain size entrenched in a polymer network [1,2]. In the off state, PDLC films have a milk-white form when the LC droplets with a +ve dielectric anisotropy are haphazardly leaning in the films. Electronic or charismatic field, the LC domain size arranges in a line direction parallel (||) to the electric or magnetic field, and the PDLCs films will switch to a clear state just about matches the polymer matrix refractive index (n_p) [3]. Based on this E-O property, their possible application as the active substrate in displays has been first projected [4], other E-O properties are important for Bathrooms/Shower enclosures, Projection displays, Hurricane resistant windows, and other devices which is increasing regularly [5-8]. Usually, there are three properties required for PDLC film (smart glass) based tool applications: a low threshold voltage for the transition between on/off states, a high on/off contrast in transmittance and a fast response time for the transition between on/off states. These E-O properties depend mainly on the structures of the heat curing epoxy monomers [9-13]; the physical characteristics of the LC such as birefringence [14] and viscosity the interface and compatibility of LC and epoxy monomers; experimental conditions [15]; the electric field conditions [16]; and fastening energy of the domain size in PDLCs system (smart glass) [17, 18].

In current years, a number of studies on the influence of the dielectric anisotropy ($\Delta\epsilon$) of the LC E-O PDLCs system have been done [19, 20]. Since the $\Delta\epsilon$ of the LC is free of the polymer, results point out that driving voltage is a falling function of the $\Delta\epsilon$ of the LC, as in the case of pure LC in cells [21]. Furthermore, it seems natural that a higher viscosity of the LC should increase both response times, other than the right viscosity of the LC inside the composite is hard to assess and it depends on a lot on the nature of the polymer, because of dissolved oligomers. In summary, LC as one main



PDLC films constituent plays a significant role in the growth of the PDLCs system E-O characteristics. In addition, polar CN- group joined by means of on the side substitutes like F atoms in various combinations generates high dipole moments (μ) which provide the increase to $\Delta\epsilon$ standards that are extra functional for dropping the threshold voltage of the PDLC films.

At nearby, despite the fact that many studies have focused on the reactive polymer catalyst to fabricate PDLC films, and a small number of researches have focal point on belongings of the LC mixture physical parameters, such as Δn , $\Delta\epsilon$ on the E-O characteristics of PDLCs systems. However, no research has been reported on effects of the LC molecular structures on the E-O characteristics of PDLCs system. In this article, NLCs has been selected due to its Characteristics for the PDLC films such as strong binding, optical clarity, strong adhesion, toughness, and flexibility effects on the terminal chain length of PDLC films. It is important to mention that adding the percentage of the thiol group (-SH) hardener, fractured the PDLC films continuously with best possible preparation condition was 40% LC, curing time 5.0 hrs at 70°C temperature. The effects of epoxy/tri functional mercaptan resins structure & E-O characteristics consequential PDLCs system cautiously examined. Similarly, the E-O substituting performance was straight dependent on LC domain. We think this study helps us not only to comprehend the relationship between the LC molecules & E-O characteristics of PDLCs system but also to find a new way to optimize the epoxy/tri functional thiol behaviour visions in structure & enhancing the E-O characteristics in curing thin glass system.

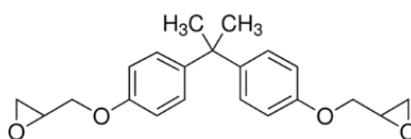
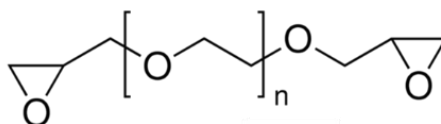
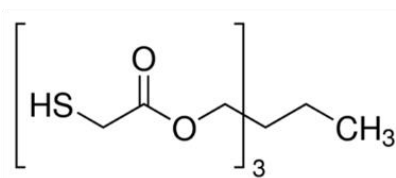
2. Materials and Methods

2.1 Materials

Fig. 1 shows the chemical structures of the materials used. In this study, the LC used contained of NLC (SLC-1717, Shijiazhuang ChengzhiYonghuaDisplay Material Co., Ltd., Shijiazhuang, P.R.China). The curable epoxy resins used were Diglycidyl ether of bisphenol A (DGEBA) (Sigma-Aldrich Company), Ethylene glycol diglycidyl ether (EGDE) resin (XY 669, Anhui Hengyuan Chemical Co., Ltd.), and Tri-methylol propane tris (3mercaptopropionate), Sigma-Aldrich Company). 3S-Thiol used as hardener for epoxy resins. Without cleansing, we used the compounds. The compositions of heating resins/3S-Thiol /NLC, as shows in Table 1.

2.2 Sample preparation

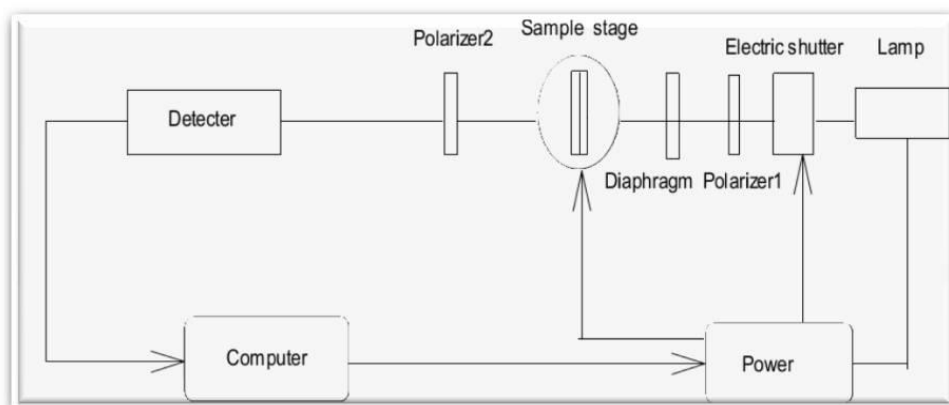
Ready samples contained of resins, tri- functional poly thiol hardener, and a constant amount of nematic liquid crystals (NLCs, 40.0wt %). First, carefully mixed in the particular mol ratio till a same blend was created. After that, based on rising liquid, the blend was packed in to the NLC cell whose internal appearances had been layered with ITO. Film thickness was controlled by a 15.0 ± 1.0 μm PET spacer. Then, prepared samples A1-A5 according to the mol ratios listed in Table 1.

1. MONOMERS**DGEBA****EGDE** $\bar{n} \approx 3.45$ **2. LC****SLC-1717** $T_{NI}=365.2K$ $n_o=1.519$ $n_e=1.720$ **3. HARDENER****TRITHIOL****Figure 1.** Chemical structures, names, and abbreviations of the materials**Table1.** The arrangements of the samples A1-A5 studied for PDLCs system

Sample	Epoxy Resins/3S-Thiol (60 wt%)	
	(5.0 hours at 70 °C)	
	EGDE/TRITHIOL/DGEBA/mol%	SLC-1717/wt%
A1	1.0/1.0/1.0	40
A2	2.0/1.0/2.0	40
A3	3.0/1.0/3.0	40
A4	4.0/1.0/4.0	40
A5	5.0/1.0/5.0	40

2.3 Analysis technique

LCD parameter tester (LCT-5016C, Changchun) used to require the E-O characteristics of the samples at ambient temperature. An electric field square wave (110 Hz) was functional and the space b/w the PDLCs system and photodiode was 350 mm. A schematic diagram of the E-O characteristics shown in scheme 1.



Scheme 1: A schematic diagram of the E-O properties

SEM(S-4800, Hitachi,) used to monitor the inner structures of the PDLCs System. The samples were initial to cut into small pieces and then soaked in n-hexane (C_6H_{12}) for 8 days at 250C to examine the LC from the polymer network. Afterward, the samples were dried under vacuum for 12 h. Then the surface of the polymer matrix was sputtered with gold and SEM to observe polymer crosslinked matrix.

3. Experimental Results and Discussion

3.1 Morphologies of the PDLCs System at 5.0 hrs at 70°C

With the purpose of appropriately quantity the droplet structure, Figure 2 shown the morphology of SEM pictures of the contract monomer network of A1-A5. The morphology of PDLCs system are reliant on the feed %age, heating situations, chemical arrangements, and on the particulars of the thin system development method [22]. The arrangement mol% of A1-A5 through 40% NLC contented & 700C curing heats is recorded in table 1. As the Figure 3 shown that the oval type droplet of the polymer matrix of PDLCs system A1-A5. 3S-Thiol responds through the epoxy group to arrange polymeric morphology scheme. Initially, the (-OH) gp: unlocked & improves another oxirane ring to arrange cross linked network chain of the PDLCs system. Furthermore, the increasing mol ratio % of the rigid chain segment and di functional epoxy resin increasing the cross-linking density consistently in all.

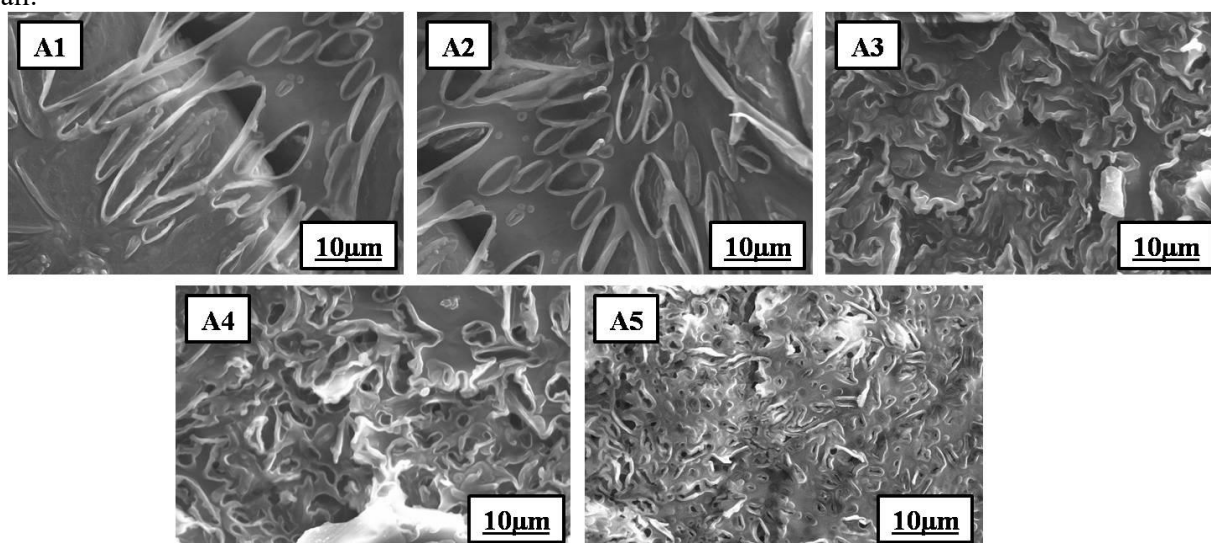


Figure 2. SEM micrographs of the polymer networks of the samples A1- A5

3.2. E-O Characteristics of PDLCs system at 5.0 hrs at 70°C

Gradually, additional oxirane and 3S-Thiolreacted shape domain size & NLCs divided from droplets, making extra and bigger droplet; before the PDLCs system became to develop easy to steer. A1 prepare with 1% each in EGDE, DGEBA, and poly thiol hardener respectively to take 5.0 hrs to acquire a PDLCs system through high-quality reaction current. At the same time, 3S-Thiol & 5.0 hrs: heating bands of samples A2, A3, A4, and A5 with constant mol ratio 1%. It shows that the samples heating for 5.0 hrs: have different E-O characteristics as sample A1-A5, As a result; it signifying to 3S-Thiol, the heating method essential merely 5.0 hrs.

The E-O effect in NLCs with an even director is not an essential condition in the presence of a warped director. Our findings have revealed a change in domain shape on the driving voltage of a PDLCs shutter with bipolar domain and investigated their effects on the polymer network, E-O characteristics, and conductivity the PDLCs system. Hence, thin film can be further successfully applied in display industries for the enhancement of E-O contrast with the specifically change of ON-scattering at minimum time. The transmission-applied voltage bands of A1-A5 are shows Figure 3. The enhancing the applied voltage, the transmission A1-A5 decreases progressively due to the increasing mol% of rigid chain segment of DGEBA.

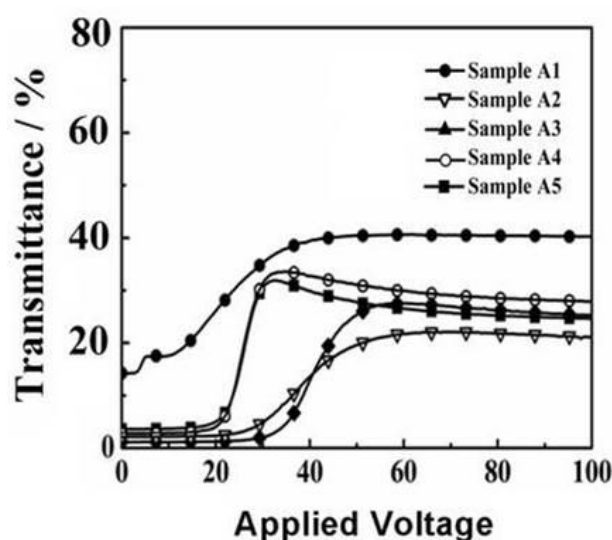


Figure 3. Applied voltage dependence of transmittance for samples A1-A5.

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$$V_{th} = \frac{d}{3a} \times \left(\frac{\rho\rho + 2}{\rho Lc} \right) \times \left(\frac{K(l^2 - 1)}{\Delta\epsilon\epsilon_0} \right)^{1/2} \quad (1)$$

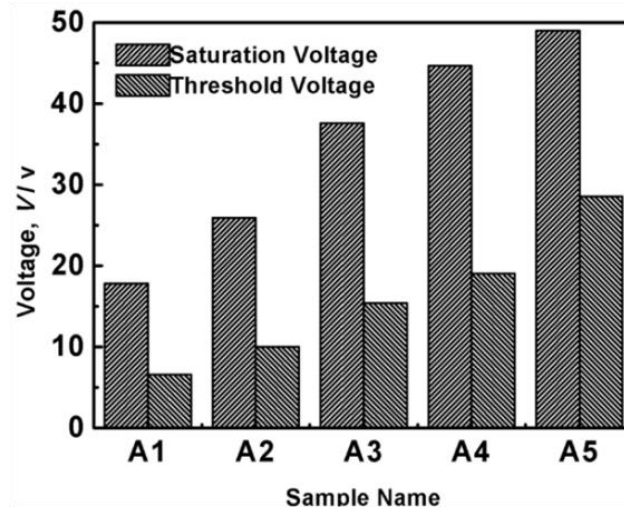


Figure 4. Saturation and Threshold voltages for samples A1-A5.

The curves of transmissibility-voltage and transmissibility-time can be obtained by the system. Analyzing the curves, the threshold voltage, saturation voltage, contrast ratio, steepness, and response time can be calculated from them as figure.4. The eq: (1) specifies the E-O characteristics of PDLCs system can be organised by LC domain size and other factors, such as film thickness, resistivity and dielectric anisotropy of LC. Hence, as shows in figure 4; V_{th} and V_{sat} increased with decreasing the LC domain size. As for samples A1-A5, increasing the rigid chain segment and increasing the cross linking density altering the values of V_{th} and V_{sat} , which changes from 6.593V to 28.571V and 17.826V to 48.979V; correspondingly.

4. Conclusions

In this study, the optimized condition for fabricating smart glass thin PDLC films containing class nematic liquid crystals (NLCs) linear chain polymer mixtures. We have been examined two PDLCs system. At 5.0 hrs at 70°C using heating oxirane resins with heat heating processes mol%, composition feed ratio, numerous molecular structures and at different mol feed ratio hardener Tri-methylol propane tris (3mercaptopropionate), which affects the E-O characteristics of the PDLC systems. Moreover, an effect on of the smart glass thin films systems was powerfully prejudiced through rigid chain segment (DGEBA), while prejudiced morphology smart films system. The outcome of the combination and thermos tropic hotness on the domain size of smart glass films were studied. Additionally, using constant mol% 3S-Thiol variable driving voltages were optimized. Our findings have revealed a change in droplet shape on the driving voltage of a PDLC shutter with bipolar droplets and investigated their effects on the morphology, E-O properties, and conductivity of the PDLC thin films. The thiol group (-SH) fractured the PDLC films continuously with changing driving voltage radically. With the enhancing content of the epoxy resins, the LC domain size decreased, while the thiol had a various effect on the LC droplet size. Hence, this thin film can be further successfully applied in display industries for the enhancement of E-O and contrast with the specifically change of ON-scattering at minimum time.

5. Acknowledgment

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