# Study on Electrical Characteristics of Chloromethylated Polyimide

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## Abstract

*The electrical performances of liquid crystal (LC) cells with chloromethylated polyimide (CMPI) alignment layers were investigated. The CMPI layer was previously reported as a multifunctional layer that does role of LC alignment and planarization layer as well as photo-alignment material with high photosensitivity and excellent thermal stability. The capacitance-voltage (C-V) characteristics of LC cells with CMPI alignment layers were measured. Mechanical rubbing of the CMPI layer did not generate much difference in residual DC when compared to commercial PI. However, the LC cell with photo-oxidation CMPI layer shows a high residual DC value and a corresponding low voltage holding ratio (VHR) due to the photo-induced ionic charges on the alignment layer.*

## 1. Objective and Background

The photoalignment of liquid crystal (LC) is non-contact rubbing method and it is expected to make next generation liquid crystal display (LCD) [1, 2]. Recently, rubbing method is main part in LC alignment but it raises several points by directly physical contact [3]. Origination of static electricity and absorption of dust are merely an instance among the many. Especially, residual DC is main issue in these points. An image sticking is generated by residual DC potential. This is originated from adhesion of ions on the alignment layer surface, polarization between dielectric layers, and discordance with RMS voltage between odd and even frame when applying AC voltage in the module activation.

For the most part, polyimide (PI) was in general used with materials of alignment layer when processing alignment layer. But, LC alignment using a photo alignment method by irradiation of polarized ultra-violet (UV) light on an alignment layer is more sensitive and more acceptable to UV light energy at the least time. Added to that, it stands against high temperature of strong UV light and it has efficient thermal stability. Chloromethylated PI (CMPI) has high photo sensitivity and high thermal stability. Also, it is modified polyimide that functions as both an alignment layer for the LC and a planarization layer (called overcoat layer) covering color filter layer [5]. In the previous research, we described synthetic structure of the CMPI in detail [6], and reported that it was a good material as an organic layer to make LCD.

However, for the CMPI to be applied to TFT-LCDs in the upper part, especially, residual DC and voltage holding ratio (VHR) is uppermost important feature to be evaluated. In this paper, we prepared the homogenous cell (named ECB) using a commercialized PI and CMPI. Then, we evaluated electrical characteristics of the cell.

## 2. Results and discussions

Figure 1 shows the structure of CMPI polymer. This CMPI has a good solubility to some organic solvents such as DMF, chloroform, NMP and cyclohexanone, so that it can be coated on the substrate without any additional imide processes [7].

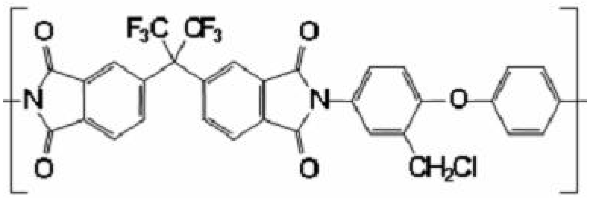

**Figure 1. Polymer structure of chloromethylated polyimide (CMPI).**

Fig. 2 shows the diagram of the simple testing system. The basic principle of capacitance is as follows:

$$Q=C^*V=C^*V_0\exp(iwt),$$
$$I=dQ/dt=C^*dV/dt=iwC^*V_0 \quad (1)$$

where $C^*$ is $I/iwV_0 = C_0(1\text{-}iD)$, $Q$ is a quantity of electric charges, $V$ is applied voltage, and $I$ is a electric current. The $C_0$ can be calculated by the known value of $I$ and $V_0$. As shown in the equation (1), the capacitance $C$ can be changed by changing of electric charges. While applying minus electric current, the charged electrons moved to the certain direction. Furthermore, applying plus electric current, the hysterisis can be taken place. Therefore, the width of hysterisis curve in C-V is residual DC [8].

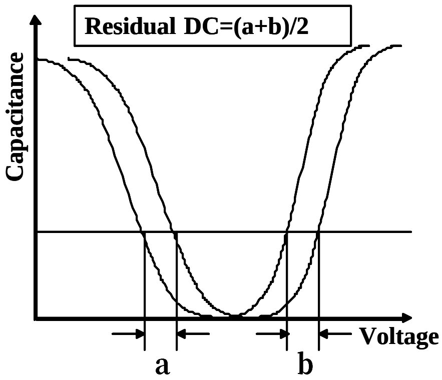


**Figure 2. Measurement principle of C-V hysteresis.**

In order to evaluate the characteristics of residual DC, we prepared an experimental cell under the condition of ECB mode. By using an AL16139(JSR) as a commercial PI, homogenous alignment layer, we pre-baked the alignment layer after coating it at 100°C for 10 minutes and then made a hardening it at 200°C for 2 hours. By using a rubbing process, we rubbed upper and lower layers and prepared cells as the structure of anti-parallel. And then, we injected superfluorinated LC mixtures with positive dielectric anisotropy of 7.4 of and birefringence of 0.088. With the same condition of the upper testing method, we coated upper and lower alignment layer by using a CMPI, and prepared cells with same method.

Capacitance with the voltage using LCR meter was measured. The voltage was applied from -10V to +10V with increment of 0.1V. In this experimental, basis for residual DC measurement were used from the area of relatively large hysteresis. Fig. 3 shows the residual DC characteristic of the cell which was fabricated using a homogenous alignment layer of AL 16139. As shown in an upward equation (1), the value (a) in the (+) region and value (b) in the (-) region is 0.025V and 0.005V, respectively. So, residual DC is 0.015V.

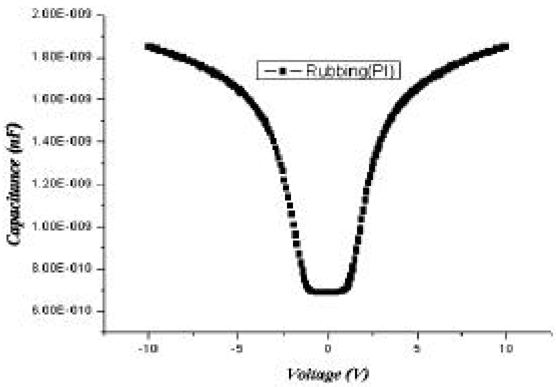


**Figure 3. Measured voltage-dependent capacitance curve of the rubbed cell with AL16139.**

Fig. 4 represents the residual DC characteristic of the rubbed cell which was fabricated using CMPI. The value (a) is 0.075V in the (+) region and the value (b) is 0.075V in the (-) region. Thus, the residual DC is 0.075V. A rubbed cell with CMPI has not shown much difference compared with commercial PI.

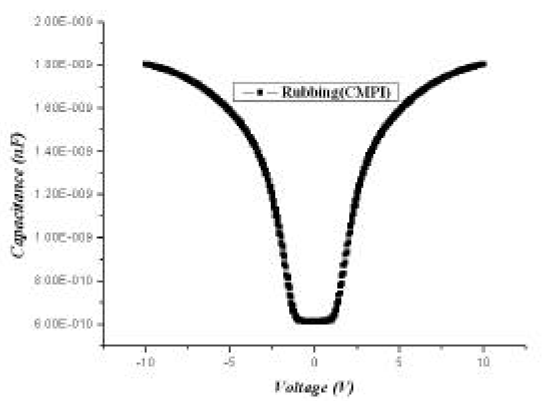


**Figure 4. Measured voltage-dependent capacitance curve of the rubbed cell with CMPI.**

Fig. 5 represents the residual DC characteristics of photoaligned cell which was fabricated using CMPI. The value (a) is 1.412V in the (+) region and the value (b) is 1.515V in the (-) region. So, residual DC is 1.463V. A photoaligned cell with CMPI has not shown any good electrical characteristics compared to a cell with commercial PI layer.

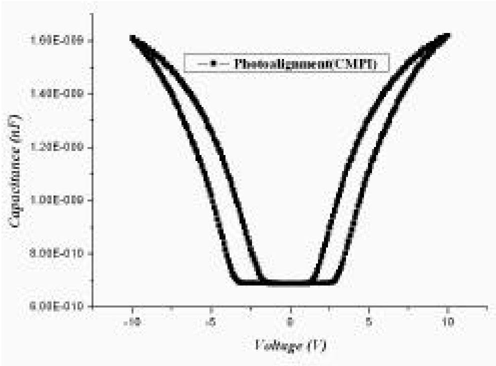


**Figure 5. Measured voltage-dependent capacitance curve of the photoaligned cell with CMPI.**

Figs. 6 and 7 show the measured voltage holding ratio (VHR). Figure 6 is representing a cell using the AL16139, and Fig. 7 is representing a photoaligned cell using the CMPI. This measurement was carried out by regarding peak to peak as 10V in both cells. As shown in Figs, VHR of the cell with AL16139 is 99.4% and VHR of the cell with CMPI is 96.94%. The LC cell with photo-oxidation CMPI layer shows a corresponding low voltage holding ratio (VHR) due to the photo-induced ionic charges on the alignment layer.

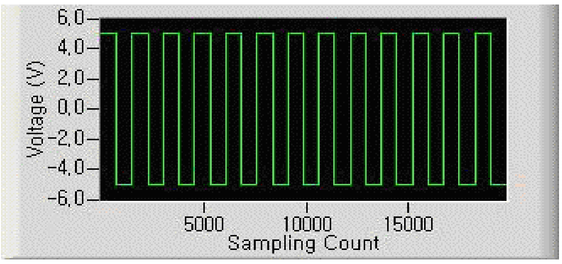


**Figure 6. The VHR of the rubbed cell with AL16139**

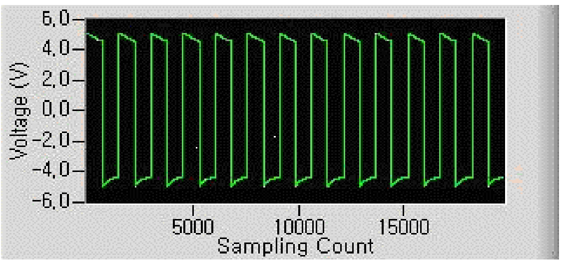


**Figure 7. The VHR of the photoaligned cell with CMPI**

A rubbed cell with CMPI has not shown difference compared with commercial PI. However, a photoaligned cell with CMPI has not shown any good electrical characteristics compared to a cell with commercial PI layer. It was confirmed from our previous research that CMPI is ready to produce amine and anhydride moieties by photo-oxidative cleavage of imide ring when exposed to deep UV light. The photo-induced ionic charge on the CMPI alignment film may contribute to the high residual DC characteristics of the photoaligned LC cell.

## 3. Impact

We have fabricated LC cells with different types of alignment layer in the ECB mode and compared their characteristics of the residual-DC and voltage holding ratio (VHR). A rubbed cell with CMPI has not shown any difference compared with commercial PI. But a photoaligned layer has not shown any good electrical characteristics compared to a cell with commercial PI layer. At last, we have concluded that inorganic materials used as a catalyst remain a little and degrade the residual DC characteristics. In the study on the CMPI, we are developing new synthetic method for acquiring pure CMPI alignment layer and making an effort to eliminate residual inorganic materials diversely.

## 4. Acknowledgements

This research was supported by the Program for the Training of Graduate Students in Regional Innovation which was conducted by the Ministry of Commerce, Industry and Energy of the Korean Government.

## 5. References

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