

## Study on the pre-tilt level and uniformity of low rotational viscosity LC for fast response time

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### Abstract

Low viscosity LCs have been developed for fast response time improvement of the TFT-LCD Monitors based on TN mode. This low viscosity characteristics cause the pretilt angle to be changed and the uniformity to degrade. We have studied on the pretilt angle effect by the various components used for low viscosity LCs. We prepared the panels by using these various components and measured pretilt angle for this research. As a result of this research, we have found out that each low viscosity component has the different pretilt angle level and uniformity. For good display quality, it is important to keep the stable pretilt angle. The low viscosity LCs with this stable pretilt angle make it possible to prepare the high performance TFT-LCD Monitor with both fast response time characteristics and good display quality

### 1. Introduction

With a large portion of TFT-LCD in the recent monitor market and the dramatic improvement of LCD technology, almost all output performances like luminance, contrast, viewing angle, color gamut and response time have been improved. Above all things, the technical improvement about the fast response time characteristics, which was very weak point in comparison with CRTs, has been achieved rapidly. This trend has driven a monitor market to even MFM(Multi Function Monitor) market also. Although TN mode has viewing angle problems, it has been considered to a decent LC mode for medium sized monitors because of its advantages for high transmittance and response time. We have kept focusing on reducing response time since 1999. We successively have launched high response time monitors as shown in Figure 1. Now, we have completed under 8ms technology and now is ready for a mass production of under 8ms product. For the accomplishment of the fast response time like this, the introduction of low viscosity ( $\gamma$ ) LC is inevitable and we have developed low viscosity LCs adequate to our response time targets(Figure 1).

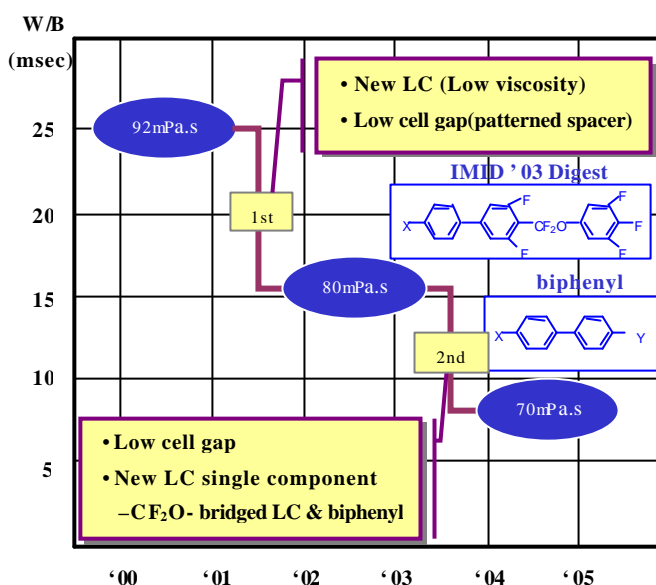


Figure 1. Response time and rotational viscosity( $\gamma$ ) trend of TN mode.<sup>1) 2)</sup>

However, because the low viscosity components used for TN mode generally bring high pretilt angle, panels with this high pretilt angle might have more problem with uniformity which brings poor display quality. In this point of view, we have studied on the pretilt angle variation effect according to the types of LC and PI materials

### 2. Experiment

#### 2.1. Sample Combination

The types of LCs and PIs used in this experiment are summarized below Table 1 & Table 2. Table 1 implies most of the achievement on fast response time was impossible without the aid of low viscosity components.

LC condition	Characteristics ( Low viscosity component included)
LC1	Neutral component with middle terminal alkenyl chain
LC2	Neutral component with short terminal alkenyl chain
LC3	Neutral component with fluorine substituted short terminal alkenyl chain

**Table 1.** Characteristics of LCs

PI condition	Characteristics
PI1	Alignment layer with long hydro carbon chain
PI2	Alignment layer with short hydro carbon chain

**Table 2.** Characteristics of PIs

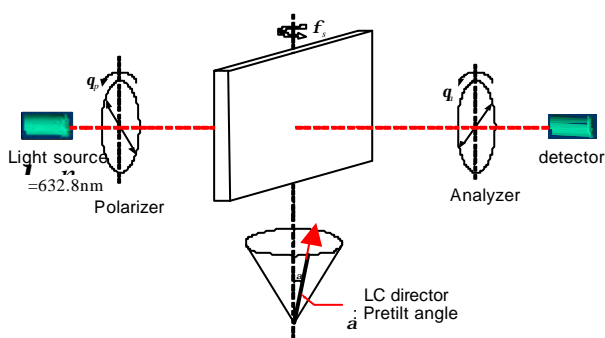
## 2.2. TN test cell fabrication

Test cells with various LCs and PIs were fabricated in our Gen.5 line (1100 × 1250).

## 3. Measurement

### 3.1. Pre tilt angle measurement

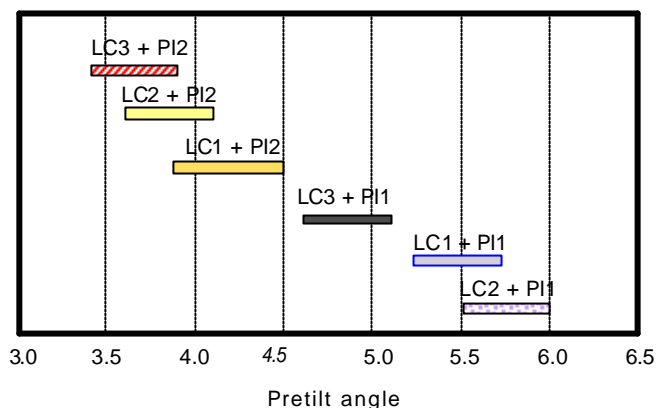
Pretilt angles of TN test cell were measured with OMS-LP5L system in our analytical center (Figure 2).

**Figure 2.** Scheme of OMS-LP5L system

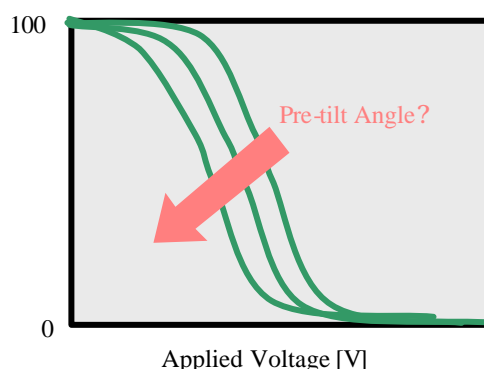
## 4. Results and discussion

### 4.1. Pretilt angle measurement result

The Pretilt angle varies from 3.0 to 6.0 degree by the combination of LCs and PIs materials as shown in Figure 3.

**Figure 3.** Pretilt angle variation according to the LC & PI material combination

As you can see, the pretilt angle mainly depends on PI types. This seems to be caused by anchoring energy difference resulted from side chain length of PI materials<sup>3)</sup>. Long chain PI with high pretilt angle such as PI1 is easy to provoke the pretilt angle uniformity degradation caused by ununiform interaction between LC and PI material during the process<sup>4)</sup>. Because pretilt angle difference in TN mode provokes the shift of EOC (Electric Optical Characteristic) curve, this difference leads the transmittance variation as the same voltage is applied to the panel (Figure 4). On the other hand it seems that PI2 having short side chains causes low pretilt angle by large anchoring energy between PI and LC material and this phenomenon is related to good pretilt angle uniformity.

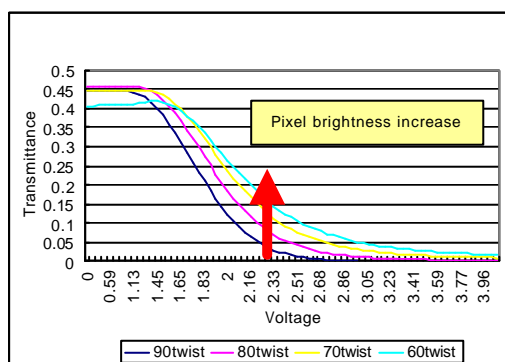
**Figure 4.** EOC curve shift as pretilt angle

As you can see from Table 1, there is a substantial amount of pretilt angle depending on LC materials. This difference is caused by main neutral component types used for each low viscosity LC. There is not big

difference on pretilt angle between LC1 and LC2, which both have normal neutral components without being substituted with fluorine but each has different terminal function length. LC3 including a neutral component substituted with fluorine shows lower pretilt angle regardless of PI material types than LC1 and LC2. It seems that fluorine substituted at terminal function of LC affects the interaction between LC and PI materials

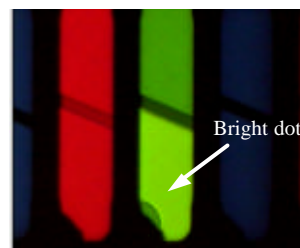
#### 4.2. Display quality evaluation result and discussion

As a result of our display quality evaluation, the higher pretilt angle conditions show the worse display quality and it was found out that LC3 + PI2 condition with the lowest pretilt angle shows the best display quality. Low pretilt angle does not always comply with good display quality. If the twist power (related with helical twist power and d/p ratio - cell gap to chiral pitch ratio) of LC is fixed, it is difficult for LC to align properly on PI material at lower pretilt angle condition. If the twist angle is far from  $90^\circ$ , it causes defects which result in light leakage. Figure 5 shows simulation result on this phenomenon using 1-DIMOS.



**Figure 5.** 1-DIMOS simulation result about domain phenomenon by under twist

It is necessary for TN cell to have moderate pretilt angle range. This light leakage is shown similar as pixel brightness phenomenon like Figure 6.



**Figure 6.** Pixel brightness phenomenon

#### 5. Conclusion

In this paper, we investigate on pretilt angle effect according to LC and PI material types and also dealt with pretilt angle stability. It is required to check the pretilt angle effect of PI and LC for both productivity and image quality.

#### 6. Acknowledgement

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#### 7. Reference

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