Advanced Liquid Crystal Materials for Monitor and TV Applications

Introduction of New Technical Centre for Liquid Crystals in Korea

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Abstract

Vertically Aligned (VA) technology is an advanced technology for TFT-LCDs, which is mainly used in larger size displays like monitors for desktop computers and even for TVs. We will review our recent developments of Liquid Crystal (LC) mixtures for VA display modes.

1. Introduction

Since the introduction of TFT LCD Notebooks in the early 1990s, the technology has been significantly improved through higher resolution, wider viewing angle, faster switching time, higher brightness and lower power consumption, etc. Advanced TFT LCD modes such as TN with compensation films, In Plane Switching (IPS) [1] and Vertically Aligned (VA) [2, 3] are essential to fulfill the required performance levels of modern desktop and industrials monitors. Indeed these modes have enabled LCDs to make a remarkable growth in share in the CRT-dominant monitor market.

The next challenging task for LCDs is to penetrate into TV applications in which the technical key requirements are somewhat different to those for desktop monitor application. Higher resolution is needed for monitors while enhancement of brightness is more important factor in TV application. However, fast switching time is required by both TV and Monitor, especially multi-media usage purposes.

The VA mode is one of the newest LCD technologies, which can play an important role for both Monitor and TV application. The VA mode employs a homeotropic alignment of the liquid crystal molecules on an orientation layer. The utilized liquid crystal mixtures have negative dielectric anisotropy ($\Delta\varepsilon<0$) in order to align perpendicular to an applied electric field. Although the switching times of VA modes are intrinsically very fast, a further reduction of the gray scale switching is still necessary to fulfill TV requirements. The switching speed of LCDs is a relatively complicated function of driving voltage, optical anisotropy, elastic constants, dielectric anisotropy and rotational viscosity. However, unlike other parameters, rotational viscosity of LCs is directed related to the switching time. Thus, the new development work has been focussed on identifying LC materials, which can significantly improve the rotational viscosity of LC mixtures.

Merck Advanced Technologies Ltd. (Figure 1) has been established in order to provide local R&D production and QC for LC mixtures in Korea.

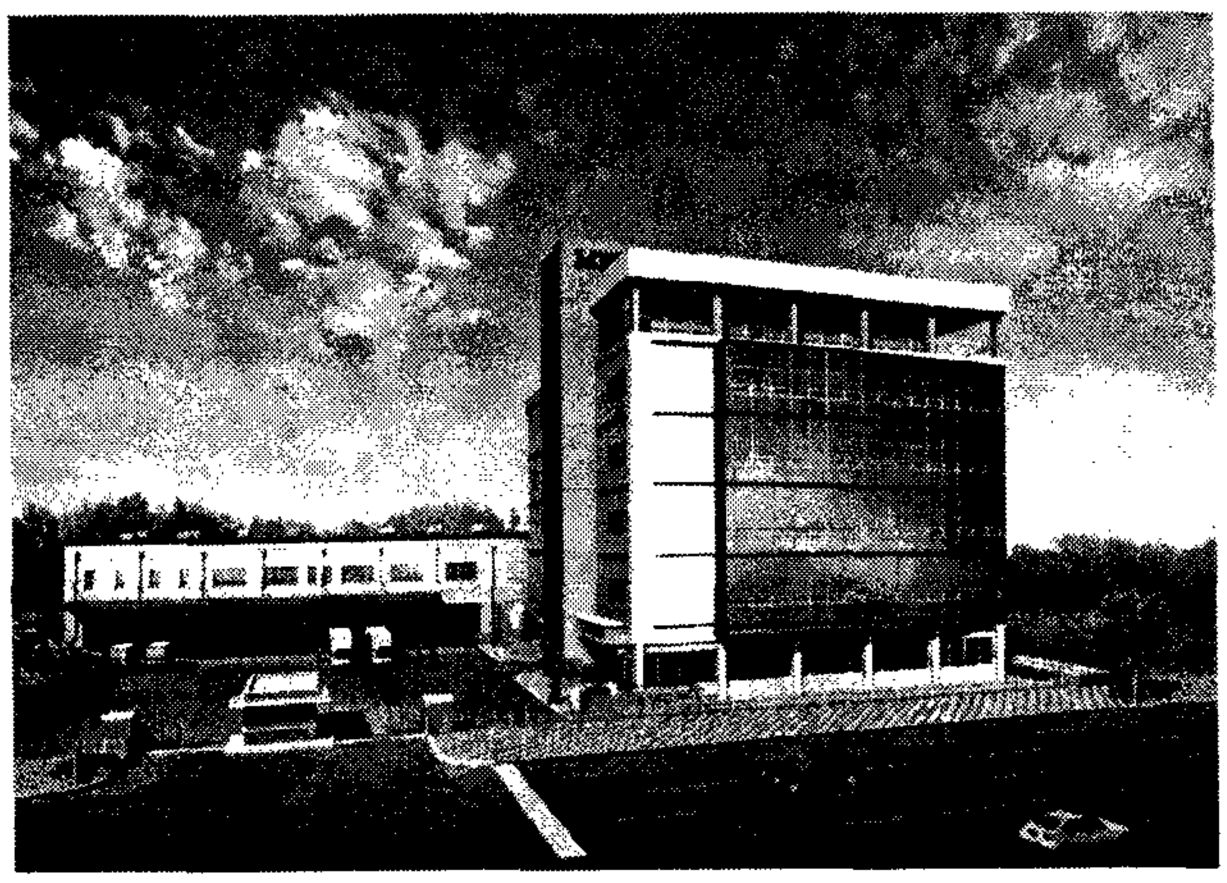

Figure 1: MAT LC Technical Centre located in Gyonggi-Do, Korea.

2. Experimental

All measurements are carried out at T = 20 °C. The threshold voltage (V_0) and the dielectric anisotropy ($\Delta\varepsilon$) are determined by the capacitive method at a frequency of 1 kHz ($\varepsilon_{\parallel}$ with a homeotropically, and $\varepsilon_{\perp}$ with a planar oriented sample), the optical birefringence Δn of the homeotropically aligned sample is measured using an Abbe refractometer (λ = 589 nm). Rotational viscosity (γ_1) is obtained from the torque of the sample in a rotating magnetic field [4].

3. Results and discussion

We successfully identified new LC compounds with large negative dielectric anisotropy, which can significantly improve the rotational viscosity and switching time for a broad range of mixture specifications while keeping all other properties.

In Figure 2 the switching time parameter $\gamma_1/\Delta n^2$, which is proportional to the switching times τ_{on} and τ_{off} if d*Δn=const. [5, 6] where d is the panel cell gap, is shown for mixtures with different Δn, but similar clearing point (T_{NI}) and threshold voltages (V_0). Using the new materials a significant improvement is obvious for the investigated Δn-range between 0.08 - 0.13.

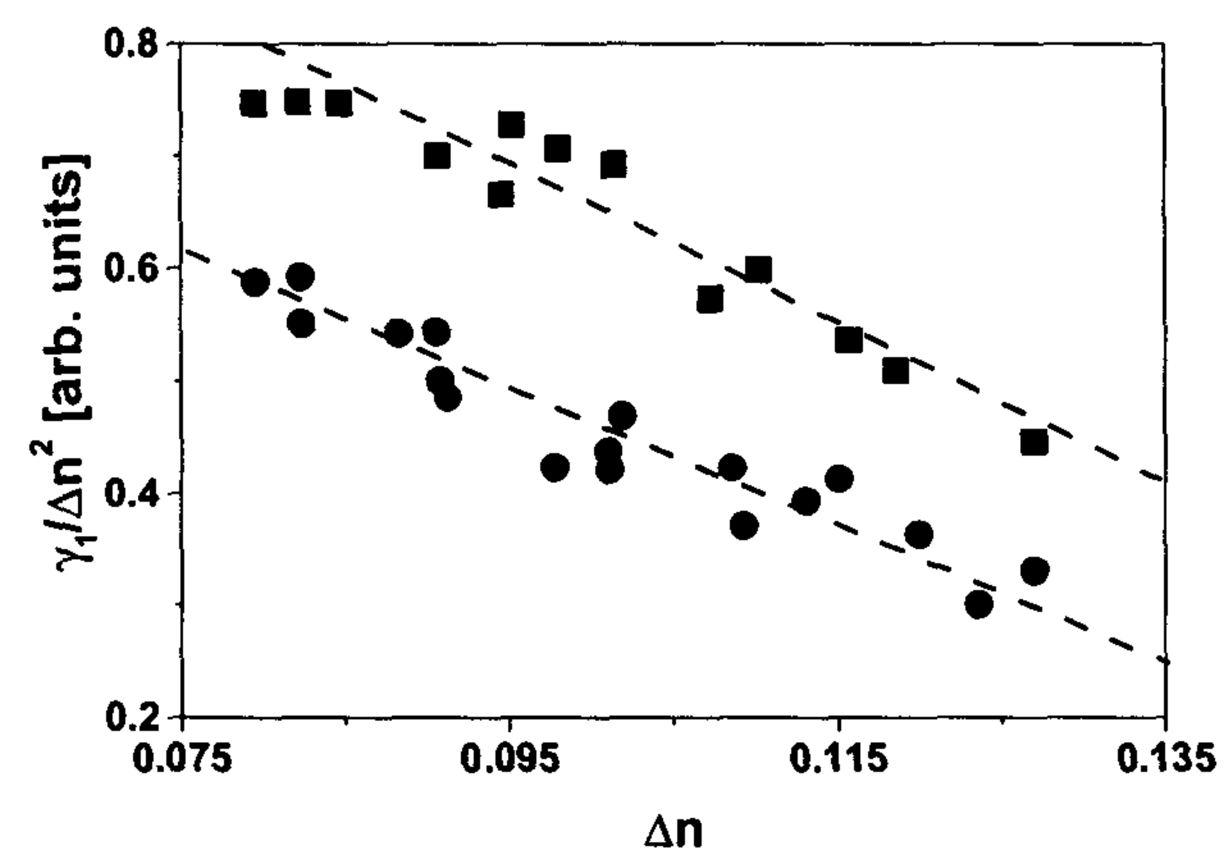

Figure 2: Dependence of the switching-time parameter $\gamma_1/\Delta n^2$ on the optical anisotropy Δn of reference (■) and new mixtures (●) with T_{NI} = 70 - 75 °C and V_0 ~ 2.10 V.

An increase of the absolute value of $|\Delta\varepsilon|$ to reduce the threshold voltage (V_0) leads to an increase of the rotational viscosities (γ_1) as shown in Figure 3. Again, for the investigated range a significant improvement of $\gamma_1/\Delta n^2$ could be achieved with the new materials compared to the reference mixture concept.

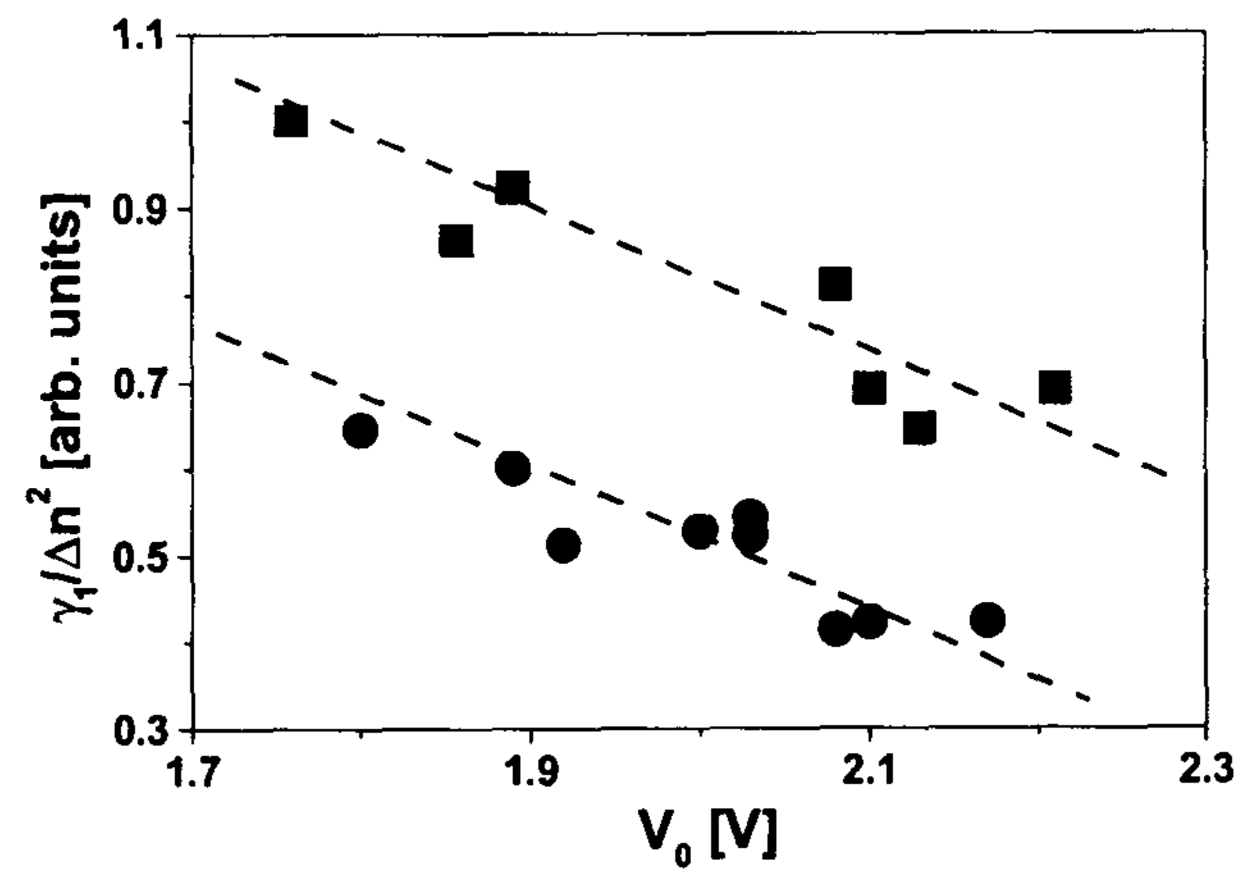

Figure 3: Dependence of the switching-time parameter $\gamma_1/\Delta n^2$ on the threshold voltage V_0 of reference (■) and new mixtures (●) with T_{NI} = 70 - 75 °C.

In order to improve panel brightness especially for TV applications, stronger backlights are used which can lead to a slightly higher operating temperature of the panel. Therefore, LC mixtures with higher clearing points up to 90°C are needed. There exists an intrinsic trade-off relation between the clearing point of a LC mixture and the corresponding rotational viscosity γ_1. Higher clearing points lead to increased values of γ_1. Due to the good relationship between clearing point and rotational viscosity of the new materials, for a broad range of clearing points the rotational viscosities could be reduced by keeping the threshold voltage (Figure 4).

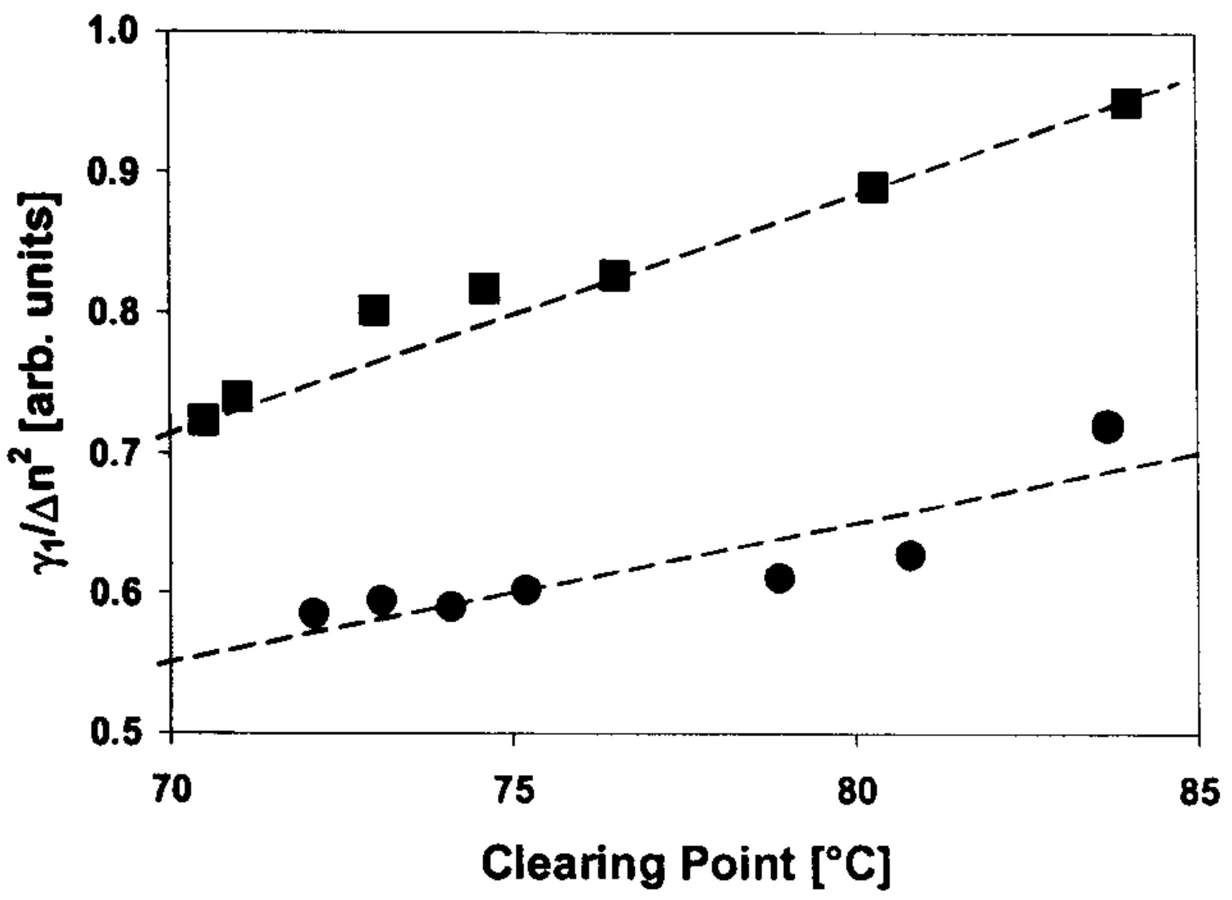

Figure 4: Dependence of the switching-time parameter $\gamma_1/\Delta n^2$ on the clearing point of reference (■) and new mixtures (●) with V_0 ~ 2.10-2.15 V and Δn=0.080-0.085.

4. Conclusions

Currently the most important goal for LCD manufacturers is the reduction of switching times in liquid crystal displays. We have succeeded in identifying new LC materials with large negative dielectric anisotropies, high clearing points and extremely low rotational viscosities. The use of these materials results in LC mixtures with significantly reduced rotational viscosities and switching times when compared to conventional materials for VA-LCDs.

5. References

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