

Liquid Crystal Mixtures of High Response Time and High T_{NI} for LCD-TV Application

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1. Abstract

In order to develop liquid crystal mixtures of high response time and high nematic-isotropic transition temperature (T_{NI}) for LCD-TV application, novel liquid crystal molecules with a fluoro-isothiocyanate moiety were synthesized. They showed remarkably high T_{NI} over 200 °C, wide mesophase range of 170 °C, high dielectric anisotropy of 14 and high optical anisotropy of 0.19. New LC Mixtures of the high T_{NI} (85~100 °C) and fast response time (8~10ms) were blended with the novel fluoro-isothiocyanate containing LC molecules, phenylcyclohexanes, bicyclohexanes and ester compounds. It was also studied on optimum pitch of liquid crystal for high speed twisted nematic LCD-TV application. The LC mixtures show a fast speed of the below one frame rate in real 17" TV panel.

1. Objectives and Background

TFT-LCDs is widely progressed to notebook PCs, monitor, mobile phone or PDA, and so on. Next ambitious target of TFT-LCDs is LCD-TV application. Liquid crystal response time applied to current LC device ranges from 20 to 30 msec. In principle, liquid crystal response time should at least faster than one frame time, 16.7 ms for moving picture. Therefore, final targets in LCD-TV are a fast speed and wide temperature range, low power consumption and a wide viewing angle. These properties are closely related to the physical properties, which depend on molecular structure of liquid crystal materials. In order to achieve the requirements, we developed fluoro-isothiocyanated liquid crystals, which are reported in a variety of peculiar physical properties in comparison with SFMs (super fluorinated materials) [1~3]. They have high nematic-isotropic temperature, wide nematic range,

high dielectric anisotropy and high optical anisotropy. The response time depends on pitch of liquid crystal [4].

In this paper we will discuss the physical properties of these single materials and a new LC mixtures. Also, we will report to the pitch that is the important factor determining response time at twisted nematic LCD.

2. Result

2.1 Synthesis and Measurements

The fluoro-isothiocyanated liquid crystals, which are listed in Table 1, were synthesized through many reported references [1~3,5]. The chemical structures and purities of synthesized materials were confirmed by $^1\text{H}/^{13}\text{C}$ -NMR spectroscopy, mass spectroscopy and gas chromatogram. The purities were more than 99.9%. The cell gap was 3.7 μm , and the applied voltage for electrooptic properties was 0-5volt at 25°C.

2.2 Physical properties

Table 1. The physical properties of synthesized materials

Material Code	T_{CN}	T_{NI}	$\Delta\epsilon^*$	Δn^*
SM-A	81.5	237.4	11.7	0.198
SM-B	65.7	215.7	14.1	0.183
SM-C	56.9	226.8	9.7	0.174
SM-D	62.9	202.4	12.1	0.199
SM-E	72.9	189	9.8	0.163
SM-F	81.1	175.2	14.2	0.169
SM-G	60.9	186	9.2	0.164
SM-H	50	175.3	11.1	0.167
SM-I	29.5	44	8.1	0.151
SM-J	9	33.2	8.8	0.137

*Extrapolated values from 17 wt% solution in commercial liquid crystal mixture at 25°C

As shown in Table 1 we have already reported the physical properties of synthesized single molecules[1]. In summary, all the homologues of SM-A~SM-F series show remarkably high nematic-isotropic transition temperature (T_{NI}) points (175.3 ~ 237.4 °C) and wide nematic temperature ranges (up to 169.9 °C for SM-1C). The dielectric and optical anisotropy values are higher than corresponding SFMs⁶ and vary according to core, terminal group and alkyl spacer length.

A relationship between nematic isotropic transition temperature (T_{NI}) and response time shown in Fig.1. The new LC mixture manufactured with single key material to host LC mixture. Response time of the new blended LC mixture is increased with an increased in nematic isotropic transition temperature (T_{NI}). They have shown general trend. However, SM-E have shown a high T_{NI} and fast response time relative to other materials.

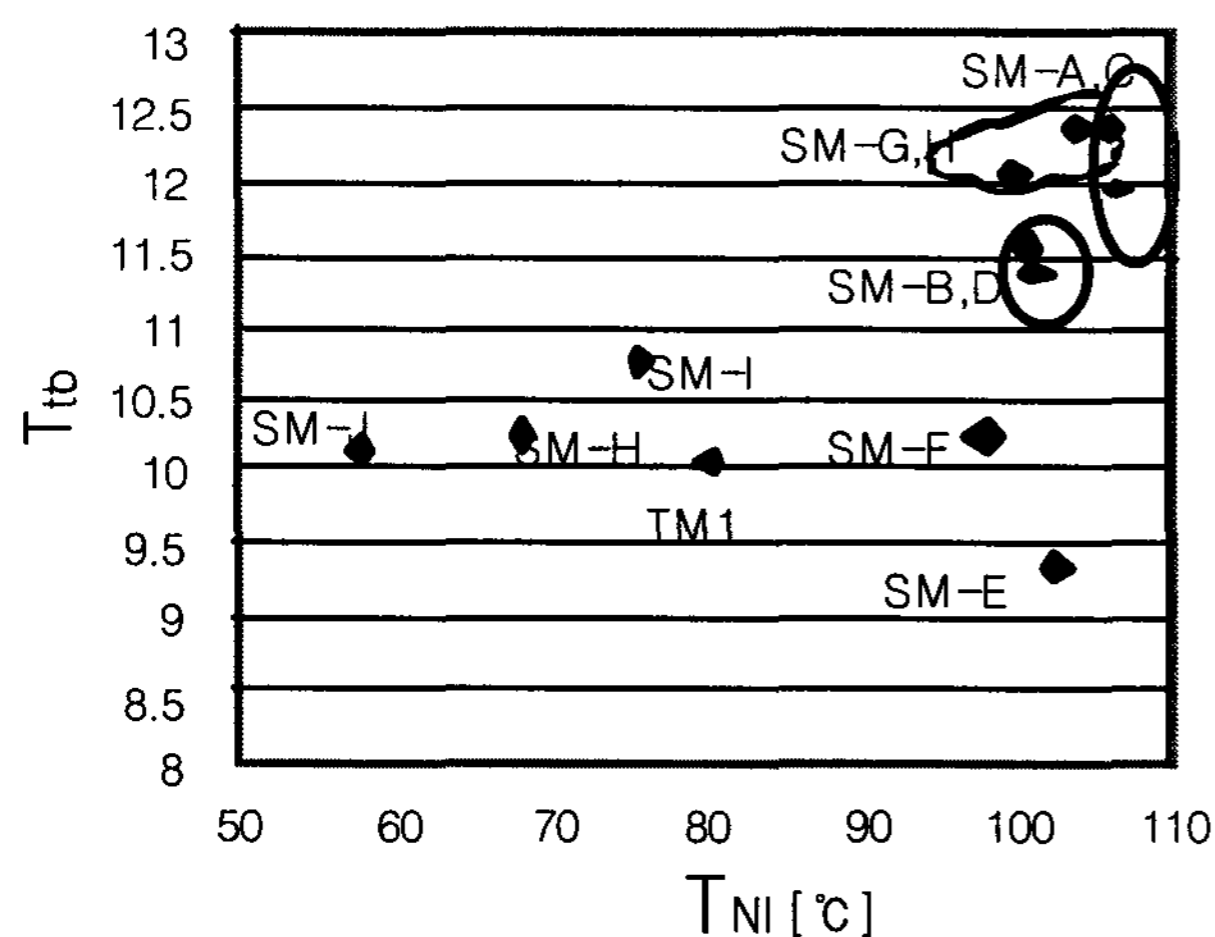


Fig. 1 A relation between T_{NI} and response time (T_{total}) of the LC mixture. (They were blended single materials (17%) to host mixture (TM1))

Host LC mixture have mesophase range of the -25~80 °C, response time 16~18ms in test cell. However they have the response time of the 20~25ms with a real panel. Therefore it is not responsible to moving picture. But, the new LC mixture have response time of the 9~12ms and high T_{NI} of the 90~100 °C except for two ring compounds as key material. These appearances assumed that rotational viscosity to elastic constant of NCS Series have small relative to Fluoro series compound.

2.3 Mixture including fluoro-isothiocyanated materials

Fluoro-isothiocyanated materials, phenyl-cyclohexanes, bicyclohexanes and ester compounds were blend for LCD-TV application. In order to improve wide nematic phase range we

considered the eutectic temperature from Schroder-van Laar's law. The mixtures are shown in Table 2. They have high T_{NI} , fast response time, suitable threshold and saturation voltage, and pitch (98µm).

Table 2. The physical properties of mixture including fluoro-isothiocyanated materials

	SM1	SM5	SM6	SM8
T_{CN}	<-25	<-25	<-25	<-25
T_{NI} (°C)	102.6	86.5	103	100.5
$\Delta\epsilon$	6.01	6.8	6.17	6.4
Δn	0.09	0.1046	0.0952	0.103
τ_{on}	1.7	1.8	2.2	1.7
τ_{off}	10.2	9.0	8.6	8.6
τ_{total}	11.9	10.8	10.8	10.3
V_{th}	1.6	1.5	1.6	1.5
V_{sat}	2.7	2.6	2.8	2.6

We have studied on relationship between pitch and response time. As shown in Table 3, the small pitch induces the increase of saturation voltage and the decrease of turn-off time.

Table 3. The relationship between pitch and electrooptic properties

Pitch	V_{th}	V_{sat}	τ_{on}	τ_{off}	τ_{total}
96	1.5	2.6	1.7	8.6	10.3
41.1	1.6	2.7	1.7	8.2	9.9
27.4	1.6	2.7	1.7	7.8	9.5
13.8	1.7	3.2	1.8	6.7	8.5

The new LC Mixture has a fast speed of the below the one frame in 17" TV panel. The panel has't defects elating liquid crystal (SM8) and has a good image. It is responsible to moving picture for LCD-TV application.

3. Conclusion

Fluoro-isothiocyanated liquid crystals have peculiar physical properties as wide nematic range, high dielectric and optical anisotropy. The New LC mixture have wide temperature range of the -25~100 °C and fast speed of the below one frame in 17" TV panel. It is responsible to moving picture for LCD-TV application.

4. Reference

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