Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl19

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Version of record first published: 04 Oct 2006

To cite this article: Yuvaraj Sah (1997): Induced Twist Grain Boundary Phase in Binary Mixtures, Molecular Crystals and Liquid Crystals Science and Technology. Section A. Molecular Crystals and Liquid Crystals, 302:1, 207-213

To link to this article: http://dx.doi.org/10.1080/10587259708041830

*Mol. Cryst. Liq. Cryst.*, 1997, Vol. 302, pp. 207–213
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# INDUCED TWIST GRAIN BOUNDARY PHASE IN BINARY MIXTURES

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Abstract We report induced Twist Grain Boundary phase formation in binary mixtures of n-nonyloxy-benzoic acid with cholesteryl sterate and cholesteryl caprylate. The (n-nonyloxy-benzoic acid / cholesteryl sterate) mixture in particular has been studied by optical microscopy, DSC, optical rotation and selective Bragg reflection.

## INTRODUCTION

The cholesteric (Ch) to smectic A ($S_A$) phase transition has an analogy with the metal to superconductor transition in the presence of an external magnetic field. Extending this analogy, Renn and Lubensky[1] proposed a new liquid crystalline state which has an analogy to the Abrikosov flux lattices in type II superconductor. This phase known as the Twist Grain Boundary (TGB) phase, was indeed discovered by Goodby et.al[2]. TGB phase is a helical stack of smectic blocks with the smectic layer normal perpendicular to the twist axis. The smectic blocks could be of $S_A$ or smectic C structures. The former and latter phases are respectively designated as $TGB_A$ and $TGB_C$. Since the discovery of the TGB phase a lot of reports have appeared confirming the existence of $TGB_A$ and $TGB_C$ phases in many materials[3]. There are also reports of the induced $TGB_A$ and $TGB_C$ phases exhibited in some binary mixtures [4–6]. It is worth noting that the binary mixtures analised in [4,6] where studied extensively even before the discovery of the TGB phases and various anomalous effects were observed [7,8]. The X-ray and optical studies in [8] even concluded that the twisted nematic phase of the mixture has a structure different from

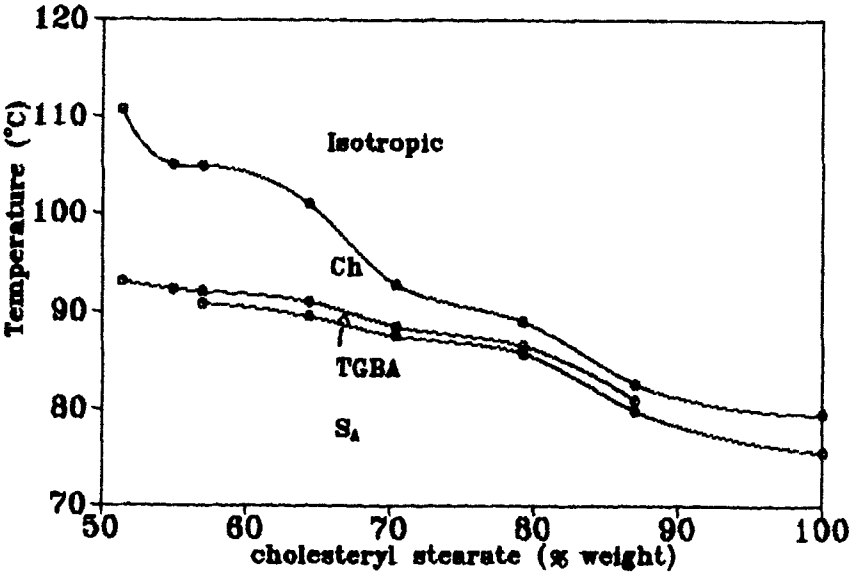


Figure 1: The temperature-concentration phase diagram obtained for the (NOBA/CS) mixture.

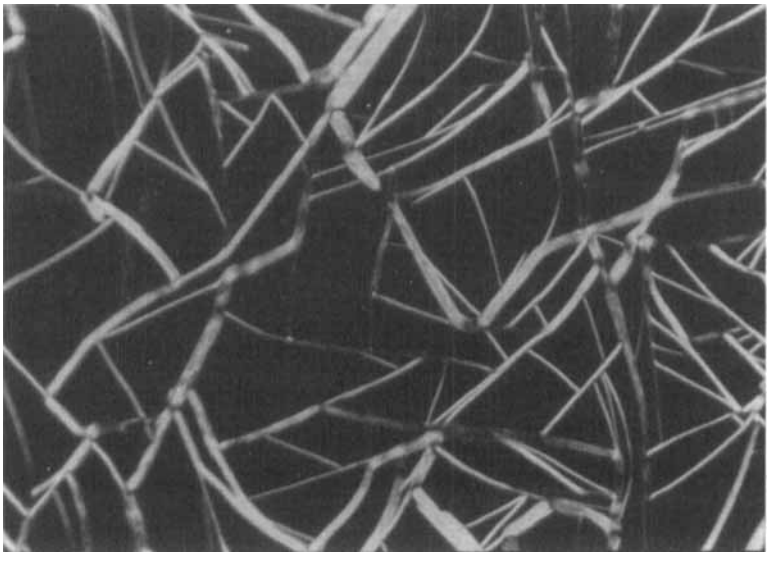

Figure 2: The micrograph taken for the (NOBA/CS) mixture for concentration $X = 0.6$ in the $TGB_A$ phase. The sample was heated from the homeotropic aligned $S_A$ phase to $TGB_A$ phase. (See Color Plate III).

the usual cholesterics, indicating an induced TGB phase.

In this paper we present results of experiments carried out on binary mixtures of n-nonyloxy-benzoic acid (achiral compound) with cholesteryl sterate (NOBA/CS) and mixture of n-nonyloxy-benzoic acid with cholesteryl caprylate (NOBA/CC). It is to be noted here that both the chiral compounds, i.e., cholesteryl sterate and cholesteryl caprylate exhibit monotropic $S_A$ phase. The observed features of the (NOBA/CC) mixture were very similar to that found in (NOBA/CS) mixture, hence are not discussed here.

## RESULTS

The temperature-concentration phase diagram was obtained using a mettler hot stage in conjunction with a polarizing microscope. This is shown in figure 1. It was found that for $X < 0.55$ ($X$ is the weight fraction of CS in NOBA) there is a direct Ch-$S_A$ transition. For $X > 0.55$ $TGB_A$ phase occurs up to $X = 0.9$. The occurrence of the $TGB_A$ phase is indicated by the appearance of the filament texture, a characteristic of the $TGB_A$ phase, when the mixture is heated from homeotropic aligned $S_A$ phase to cholesteric phase. The micrograph obtained for the concentration $X = 0.6$ in the $TGB_A$ phase is shown in figure 2. The filament texture is quite stable and remain unchanged even if left for hours at a constant temperature.

The differential scanning calorimeter scan was taken using Perkin Elmer DSC-4 instrument for $X = 0.6$ concentration. The Ch-$TGB_A$ and $TGB_A$-$S_A$ transitions have merged together and hard to be noticed. This is shown in figure 3.

For the optical rotation and the wavelength of the selective Bragg reflection measurements the cells were made using polymide coated glass plates rubbed unidirectionally. The temperature of the sample cell was controlled with the accuracy of 5 m°K using the MK1 temperature controller.

The optical rotation of the azimuth of linearly polarized is measured using a green He-Ne laser light. The planar aligned sample was kept in between the polaroids and the signal was detected using a photo diode. The output signal

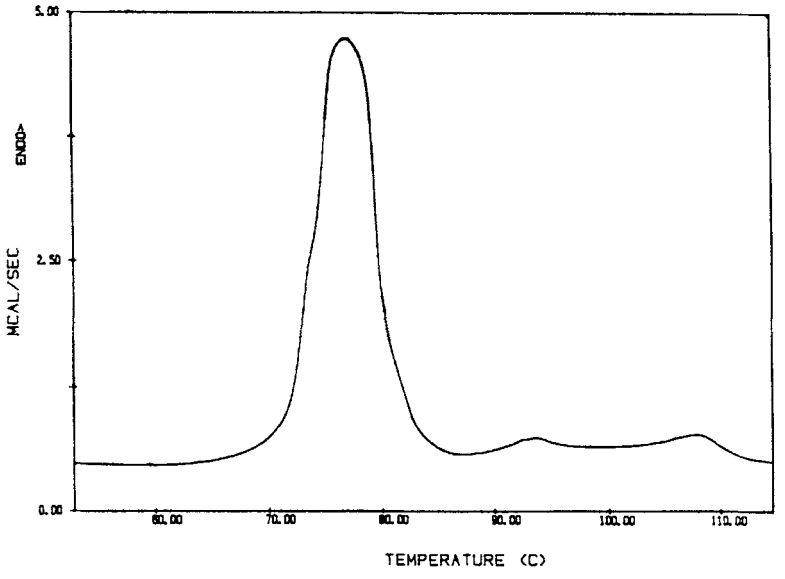


Figure 3: The DSC scan taken for the (NOBA/CS) mixture for concentration $X = 0.6$. The Ch-$TGB_A$ and $TGB_A$-$S_A$ transitions can hardly be separated.

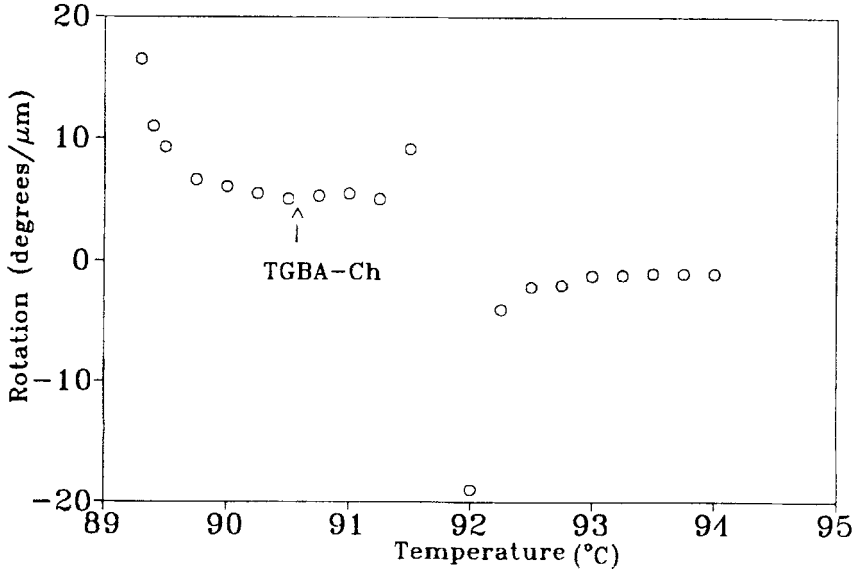


Figure 4: The optical rotation obtained for the (NOBA/CS) for concentration $X = 0.6$ in the $TGB_A$ and cholesteric phases.

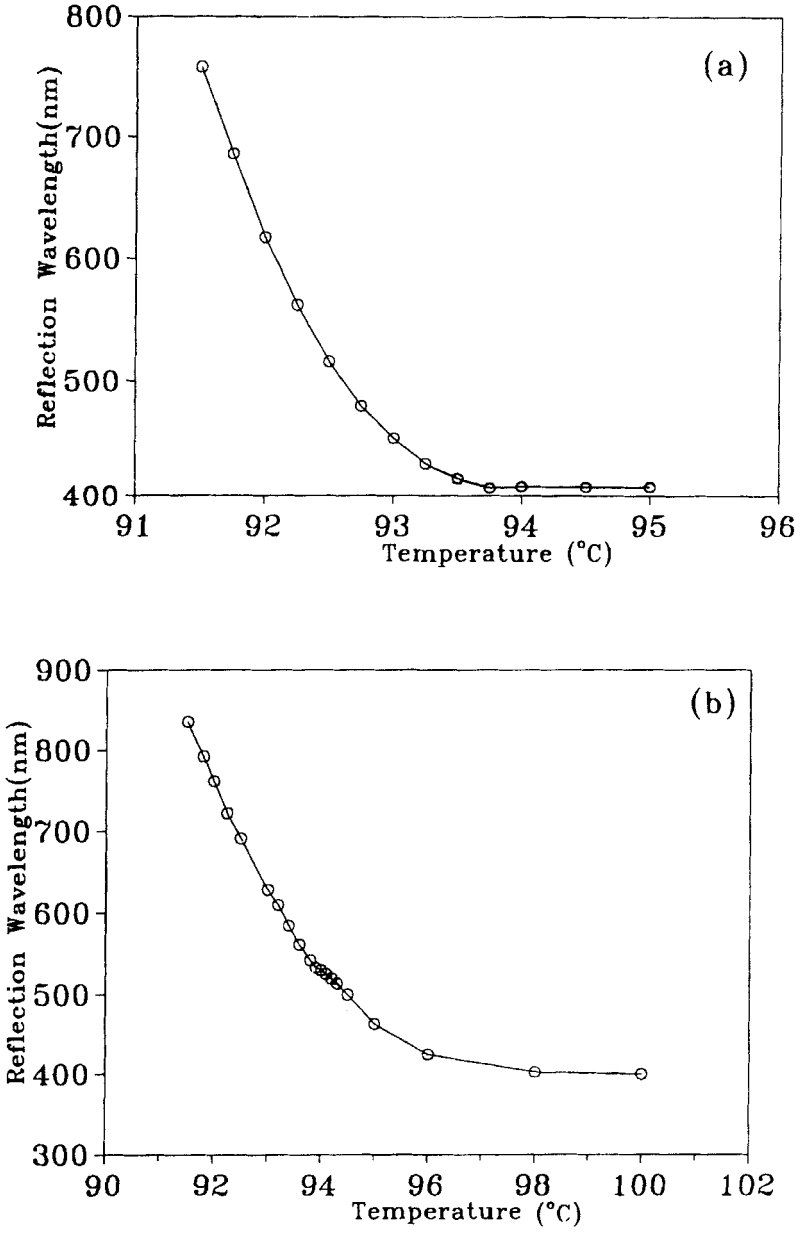


Figure 5: The measured wavelength of the selective reflection obtained for (NOBA/CS) mixture for concentrations **(a)** $X = 0.6$ **(b)** $X = 0.55$ in the $TGB_A$ and cholesteric phases.

of the photo diode was fed into a lock-in-amplifier. The measured optical rotation for $X = 0.6$ concentration is shown in figure 4. The change in the sign of rotation can be noticed as the pitch of the medium becomes greater than the wavelength of the incident light. One can notice a sudden increase in the optical rotation at the Ch-TGB$_A$ transition. The optical rotation in the induced TGB$_A$ phase confirms its helical structure.

The wavelength of the selective Bragg reflection is measured using a Hitachi spectrometer for the sample aligned in the planar geometry. The wavelength measurements could be done only in the visible range because of the limitations of the instrument. The measured wavelength of the selective reflection as a function of temperature is shown in figure 5a and 5b for the concentrations $X = 0.6$ and $X = 0.55$ respectively. Though the optical pitch of the TGB$_A$ phase for $X = 0.6$ was found to be in the IR region, whereas for $X = 0.55$ the optical pitch lies in both optical and IR region.

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Part of this work was done at Raman Research Institute , Bangalore. Thanks are due to K.A. Suresh and N. Kasthuria for useful discussions.