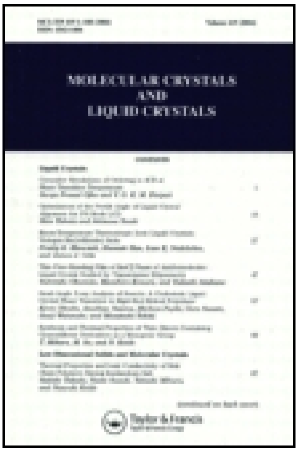

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Anamalous Selective Reflection at Cholesteric-to-Smectic A Phase Transition

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ANOMALOUS SELECTIVE REFLECTION AT CHOLESTERIC-TO-SMECTIC A PHASE TRANSITION

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Abstract An anomalous selective reflection more then 50% of input unpolarized light was observed near the cholesteric to smectic A phase transition in three-component mixtures of two nematics and optically active non-mesogenic dopant.

INTRODUCTION

For a long time we studied chiral liquid crystal systems (cholestsrics, chiral C smectics, blue phases). Mostly chiral systems with an induced helix were investigated. Such systems represent mixtures of achiral liquid crystalline compounds with mesogenic or non-mesogenic chiral dopants. Investigations had the aim to light the chirality phenomenon on the one hand and to solve some application problems the second one. The results were published in reviews[1-6]. For practical using in thermography and electrooptics some new nematic-chiral mixtures were suggested[7,8]. It was shown, that to obtain high steepness of temperature dependence of helical pitch (P), it is necessary to use optically active dopants with high helical twisting power and with molecular structure providing negative temperature dependence of the pitch. Tigogenin derivatives satisfy these conditions[9]. If a smectogenic substance is used as a nematic host, the typical picture of pre-transitional phenomena is observed[10]. The divergence of the helical pitch near the cholesteric - smectic A phase transition theoretically was considered by de Gennes as an analogy between superconductors and smectics A[11].

In this paper we report an optical observation of induced chiral systems near the cholesteric to smectic A phase transition.

EXPERIMENTAL RESULTS

We have investigated liquid crystals with following phase sequences in ^{o}C:

4-cyano-4-octylbiphenyl (8CB)

$Cr-21-S_A-32.5-N-40.5-I$

4-n-hexyloxyphenyl-4 -n-octyloxybenzoate (HOPOOB)

$Cr-55.0-S_C-65.0-N-89.0-I$

As an optically active dopant non-mesogenic tigogenin caprate (TC) was used.

We studied two- and three-component mixtures possessing Bragg reflection in visual range in the cholesteric phase. Temperature dependences of transmission spectra were measured by spectrophotometer Specord M40. The temperature was kept constant with accuracy to $0.02^{o}C$. The surfaces were rubbed for obtaining planar cholesteric structure.

Temperature dependences of Bragg wavelength (λ_B) for two-component mixtures are shown in Figure 1. In these mixtures optical properties are conventional: for well aligned Grandjean (planar) cholesteric texture the intensity of Bragg reflection is approximately 50% for normal incidence of light.

For three-component mixtures at the certain percent correlarion of components the anomalous selective reflection near the transition into the smectic A phase is observed. The transmission spectra for unpolarized light for mixture 82% (80% 8CB + 20% HOPOOB) + 18% TC on cooling are shown in Figure 2, and temperature dependence of λ_B is shown in Figure 3. For the cholesteric phase the output intensity (I) is equal to 50% of the input intensity (I_o) at the conventional selective reflection band. The Bragg wavelength increases with decrease of temperature. Near the transition into the smectic A the Bragg wavelength stops

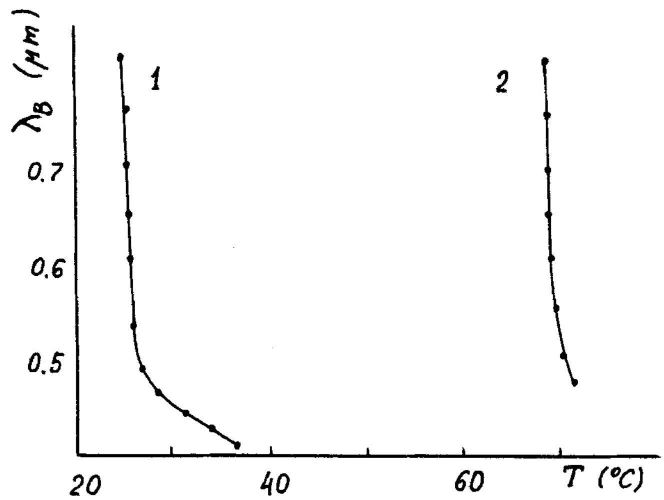

FIGURE 1 Temperature dependence of Bragg wavelength on cooling for two-component mixtures: 82% 8CB + 18% TC (1) and 82% HOPOOB + 18% TC (2).

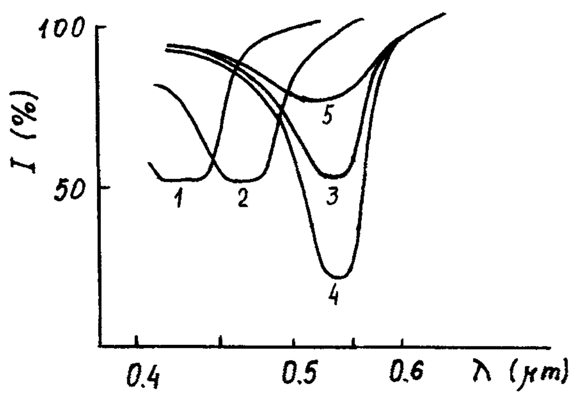

Figure 2 Bragg peaks for three-component mixture on cooling for different temperatures: 44.2°C (1), 42.9°C (2), 42.1°C (3), 42.0°C (4), 40.8°C (5).

changing ($\partial\lambda_B/\partial T=0$). The Bragg reflection intensity increases up to 0.8 I_0 and then decreases and becomes zero at the smectic A phase.

This unusual state is thermodynamically stable and takes temperature interval approximately 1.5°C. The phase transition temperatures in °C, determined by polarizing microscope on cooling, are:

I-46.6-BPI-44.8-Ch-42.1-transition state-40.5-S_A-25-Cr

The transmission for circularly polarized light is

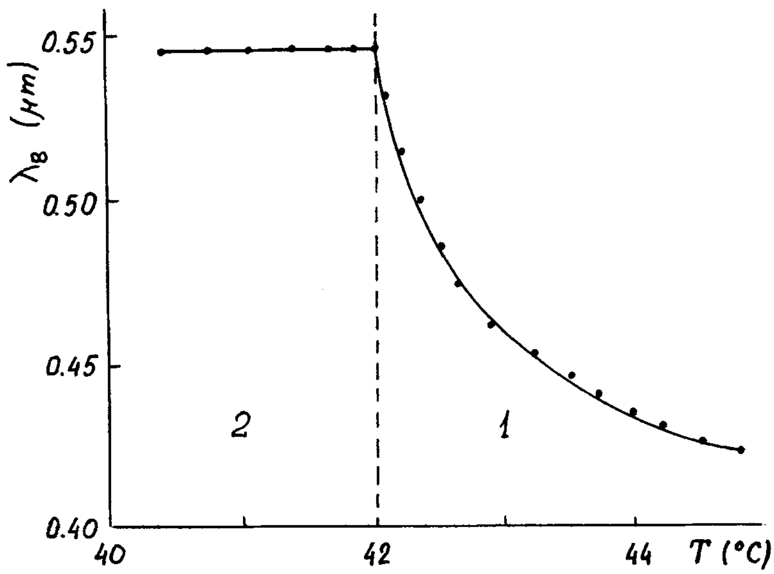

FIGURE 3 Temperature dependence of Bragg wavelength for three-component mixtures on cooling in the cholesteric phase (1) and in the transition state (2).

measured also. In Figures 4, 5 and 6 temperature dependences of transmission intensity in the investigating state for unpolarized, right- and left-handed circularly polarized light accordingly are shown. Each point corresponds to the maximum of the Bragg peak.

The wavelength and the intensity of the anomalous selective reflection are due to the concentration correlation of components of the mixture. But for each of the mixture in the describing state the condition $\partial\lambda_B/\partial T=0$ is kept.

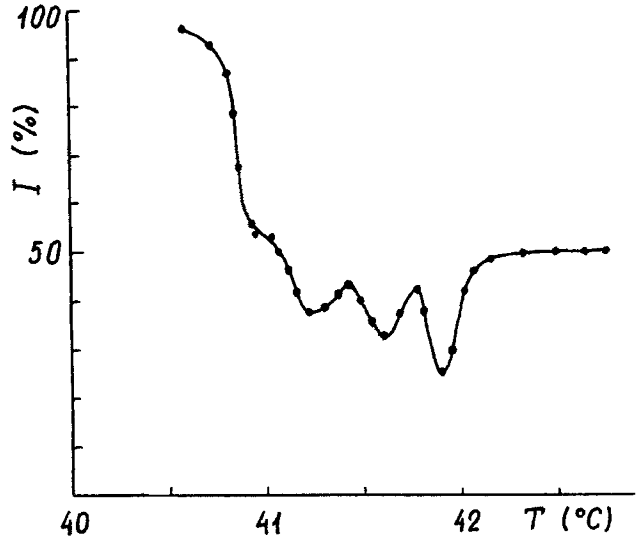

FIGURE 4 Temperature dependence of optical transmission at the Bragg wavelength for unpolarized light.

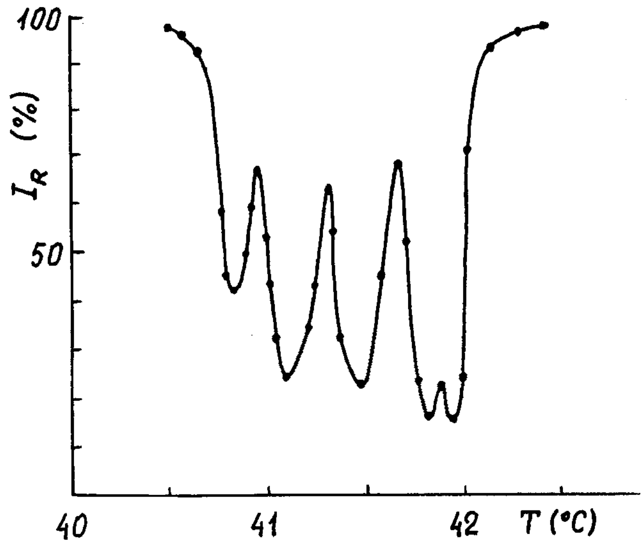

FIGURE 5 Temperature dependence of optical transmission for right-handed circularly polarized light.

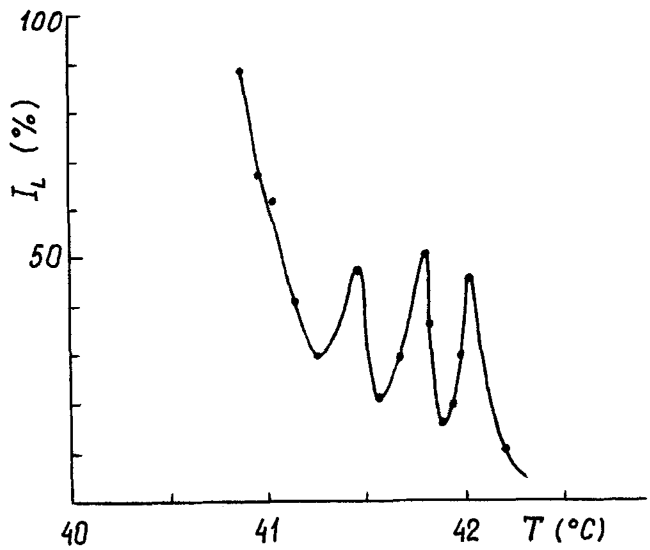

FIGURE 6 Temperature dependence of optical transmission for left-handed circularly polarized light.

CONCLUSION

In mixtures of two nematic substances 8CB and HOPOOB with optically active non-mesogenic tigogenin caprate the anomalous selective reflection near the phase tratsition cholesteric - smectic A was observed. According to Belyakov, Dmitrienko and Orlov[12] for oblique incidence of unpolarized light the reflection coefficient R depends on the angle of incidence and may reach 1 (total reflection). In so called mosaic texture, consisting of flat cholesteric domains inclined to the surfaces, the reflection coefficient is more than 0.5. But the angles of inclination of domains are different, therefore the Bragg peak is wide. In our case it is possible, that the Grandjean texture tiltes near the phase transition and formes a kind of mosaic texture, where the domains have the same tilt angles, therefore the widening of Bragg peak does not take place. The increase of the pitch is compensated by increase of the tilt of the domains, thus $\partial\lambda_B/\partial T=0$.

On the other side, as we mentioned in the introduction, the cholesteric - smectic A phase transition may be considered as an analog of normal - superconductor phase transition. According to Renn and Lubensky[13] near the phase transition an intermediate phase can be formed and stabilized by screw dislocation. This predicted phase they called "twist grain boundary" (TGB) phase. Recently this phase was observed by Goodby et al[14]. A mixture of two nematics with different smectic phase sequence (like 8CB and HOPOOB) used as a nematic host is an expected candidate for observation of TGB phase.

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