ac-FIELD-INDUCED GRANDJEAN PLANE TEXTURE IN MIXTURES OF ROOM-TEMPERATURE NEMATICS AND CHOLESTERICS

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The influence of ac fields on liquid-crystal mixtures of the nematic anisylidene-*p*-*n*-butylaniline (ABUTA) and the cholesteric oleyl cholesteryl carbonate was investigated. It was established that the cholesteric Grandjean plane texture could be induced with fields of the order of 2.5×10^5 V_{rms}/cm at frequencies above 0.1 kHz for samples containing 40% ABUTA. With larger ABUTA contents the frequency required to produce the Grandjean texture increased.

The influence of electric fields on cholesteric liquid crystals has been the subject of many investigations in past years.[1-3] Recently Heilmeier and Goldmacher[4] reported a reversible optical storage effect in cholesteric-nematic mixtures where erasure or clearing of the stored milky image was accomplished with ac fields with frequencies >700 Hz.

It is the purpose of this Letter to report that with suitable cholesteric-nematic mixtures, application of ac fields results in formation of the cholesteric Grandjean plane texture with all its optical attributes including reflection colors, optical activity, and a uniaxial negative interference figure. Since the Grandjean plane texture does not scatter light diffusely, layers appear clear in natural light.

The experiments reported here were carried out on nematic-cholesteric mixtures of the nematic anisylidene-*p*-*n*-butylaniline (ABUTA)[5] and oleyl cholesteryl carbonate (COC), both of which are mesomorphic at room temperature.

Mixtures of COC and ABUTA were prepared in steps of 10% by weight. All were liquid crystalline at room temperature. The isotropic transition points of the mixtures ranged between 27.7°C for the 50% mixture and 32.6°C for the 90% ABUTA sample. Sheared films between glass slides showed the characteristic visible reflection colors of cholesterics when the COC content was in the range 80% ≥ COC ≥ 30%. Colors changed from red to blue as the COC content was increased. Under a polarizing micorscope in convergent light, films with contents ≥20% COC gave a uniaxial negative interference figure. The center of the cross was absent because of optical activity. For study of the effects of ac fields, mixtures were contained between two tin-oxide-coated glass slides with a Tedlar spaced of $\frac{1}{2}$-mil thickness. Pressure effects were reduced by having a relatively large spacer with a small square opening filled with liquid crystal.

After preliminary experiments it was established that two types of measurements were of interest: First, the samples could be cleared at high frequency (2.0 kHz) and the onset of scattering measured as a function of voltage and frequency; secondly, the samples could be made scattering with low-frequency ac (20 Hz) and the clearing point measured for varying voltage and frequency. The onset of scattering is plotted as a function of electric field and frequency in Fig. 1 for films with COC contents of 20, 40, and 60%, respectively. For all compositions the field required to produce scattering decreased with frequency, while for a fixed field, scattering set in successively at lower frequencies as the COC content was increased. Samples with ≥80% COC became scattering only with dc fields and could not be made to adopt the Grandjean plane texture. In all cases, once the sample had become scattering it remained so for varying periods of time after field removal. Scattering, however, was more intense when the field was on.

Under a polarizing microscope the aspect of the scattering sites was that of a fine focal-conic texture. With increasing COC scattering became

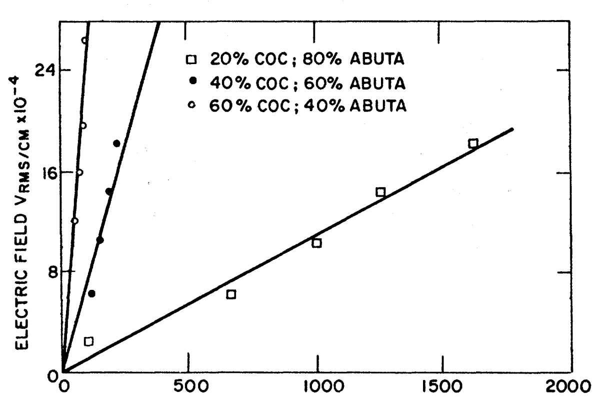


FIG. 1. Onset of scattering as a function of field and frequency.

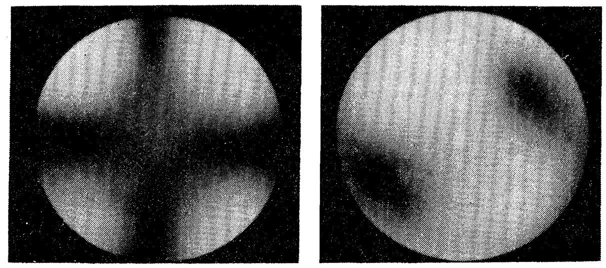
weaker, but the overall texture was maintained. Formation of light-scattering focal-conic textures due to electric fields is not exclusive to cholesteric-nematic mixtures and has been observed previously in mixtures of pure cholesterics.[6] The effect is the breaking up of the Grandjean plane texture into domains where the helical axes assume positions perpendicular to the electric field. After field removal the induced focal-conic texture also remains for long periods of time.

In the case of cholesteric-nematic mixtures, the focal-conic texture appears to be produced via dynamic scattering and not through direct action of the field as in the case of cholesterics.

Discussion will now turn to the formation of the Grandjean plane texture. Application of an ac field of adequate strength and frequency to samples whose texture has been made focal-conic resulted in adoption of the Grandjean plane texture. Prior to the discussion of the required fields and frequencies, the phenomena observable with a polarizing microscope will be described.

After application of the field the focal-conic texture vanished rapidly. Between crossed Nicols in collimated white light, the field of view became uniformly colored, corresponding to the onset of optical activity. In convergent light a uniaxial negative interference figure was observed, Fig. 2. The arms did not reach the central area which had the same hue as observed in collimated light. With increasing COC content the optical activity decreased and the cross became better defined.

On a macroscopic scale, the sample, when viewed in reflection, had the same color as the Grandjean texture produced by shear. The fields required to produce the Grandjean plane texture were of the order of $2.5\times10^5\ V_{rms}/cm$ and the frequency required depended on composition. With increasing ABUTA content alignment occurred at successively higher frequencies. Samples with 20% COC content required frequencies of 1.7 kHz or more to produce the Grandjean plane texture, whereas samples with 60% COC required only frequencies of ≈ 0.1 kHz.



(a) (b)

FIG. 2. (a) Conoscopic figure of field-induced Grandjean plane texture, $E=2\times10^5$ V/cm, $F=2.0$ kHz. Composition: 60% COC, 40% ABUTA. (b) Conoscopic figure with quarter-wave mica plate. Black dots in quadrants I and III indicate negative sign.

Since the Grandjean plane texture requires alignment of the molecules with their axes parallel to the substrate, in the present case normal to the field, one would postulate a net dipole moment normal to the molecular axes for the nematic component.

The molecular geometry of ABUTA, however, is not in complete agreement with this picture. A tentative explanation is to assume that the net dipole moment and molecular axis are at an angle such that formation of the Grandjean plane texture in the field is favored. Dynamic scattering is assumed to interfere with the alignment. Therefore, the Grandjean plane texture will only be observable if electrical conditions prevent dynamic scattering.

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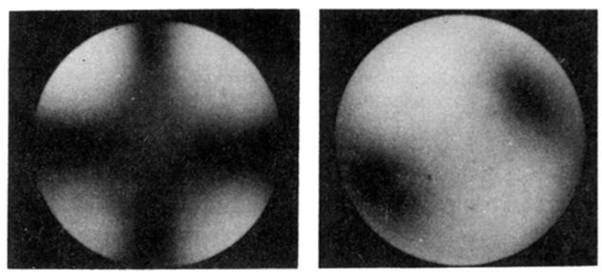

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