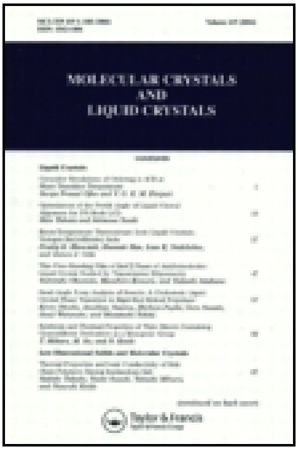

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F. Simoni [a] & R. Bartolino [a]
[a] Unical Liquid Crystal and Optics Group, Dipartimento di Fisica, Università della Calabria, 87100, Cosenza, Italy

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Voltage Controlled Polarizer Using Cholesteric Liquid Crystals[†]

F. SIMONI and R. BARTOLINO

Unical Liquid Crystal and Optics Group, Dipartimento di Fisica, Università della Calabria, 87100, Cosenza Italy

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We report the optical behavior of a cholesteric liquid crystal cell under a dc electric field. The peculiar features of the cell make it possible to use it as a voltage controlled polarizer for which an international patent is pending.

INTRODUCTION

In this paper we describe the optical behavior of a device which uses a cholesteric liquid crystal as the active medium and the distortion induced in it by an applied electric field to control the optical polarization of an incident light field.

In past years, we have reported detailed studies on the effects of a dc electric field on the optical properties of a cholesteric liquid crystal. We have shown that a field parallel to the helical axis of a cholesteric structure ($\bar{E} \parallel \bar{z}$) induces a molecular distortion[1] that changes the optical properties of the sample.[2] The optical rotation was reported to be strongly field dependent[3] for wavelengths close to the reflection peak λ_0. In the sample studied by us, the effect was related to a distortion that gave a shift of λ_0 towards shorter wavelengths. Different explanations have been given for this distortion claiming the onset of the Helfrich deformation[1] or of a pitch gradient.[4]

The variation of the rotatory power at a fixed wavelength was about 10^4 deg/mm for a narrow range of wavelengths.

[†] Presented at the Ninth International Liquid Crystal Conference, Bangalore, 6-10 December, 1982.

We report here the results of measurements made on a different type of cholesteric, with which we have made an optical device.[5] The similar optical effects induced by the electric field are in this case bigger, but the physical phenomena involved appear to be different.

The fundamental features of the problem will be treated elsewhere; the purpose of the present paper is to report the optical behavior of the device.

The liquid crystal cell is made by two conductive optical glasses in order to have the electric field parallel to the helical axis. The planar texture of the sample is obtained using a commercial surfactant on the glasses and by rubbing the two surfaces. The thickness of the sample is fixed by Mylar spacers.

The data are reported for the following cholesteric mixture: cholesteryl chloride 31.2%, cholesteryl oleyl carbonate 47.7%, and cholesteryl nonanoate 21.1%. We have used a white lamp coupled to a Jobin-Yvon H2O monochromator as a tunable light source. We measured the function $\lambda_o(V)$ (the reflection peak wavelength vs the applied voltage), tuning the incident

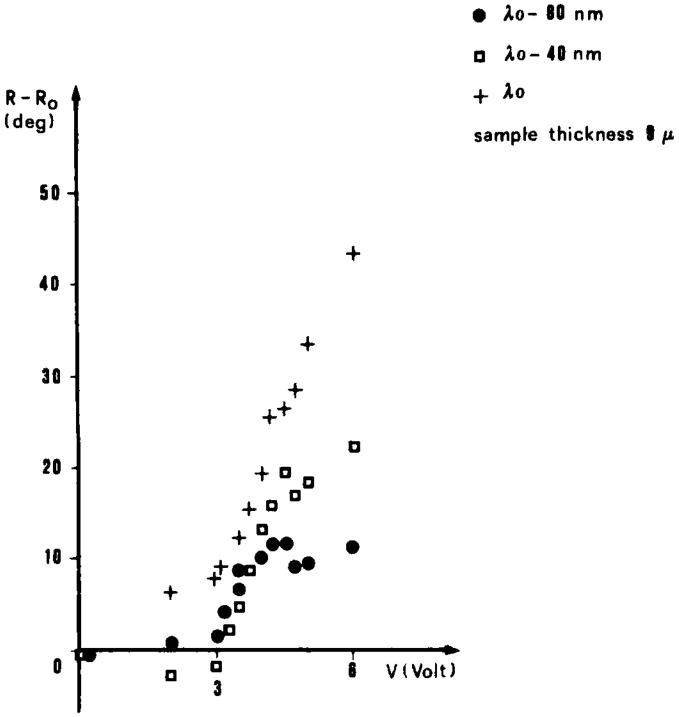

FIGURE 1 Reflection peak wavelength λ_o vs the voltage V applied to the cell λ_o increases, starting at 2.2 Volts.

light and detecting the minimum in the transmission spectrum. A typical result is shown in Figure 1, where there is evidence of a behavior different from those previously reported.[1,2,3,4] In this case we have a shift of λ_o towards *longer* wavelengths starting from 2.2 V. This apparent pitch increase (instead of the expected decrease) is probably due to different dielectric and elastic properties of the material.

The optical behavior is more interesting from an applicative point of view and is shown in Figure 2, where we report the variation of the optical rotation vs the applied voltage for different wavelengths. The measurement is performed with the cell placed between polarizers and the analyzer is rotated to find the angle of optical polarization.

Two main features are interesting. First we stress that a variation bigger than 45° is reached for an applied voltage varying from 2.2 V to 5 V, when $\lambda = \lambda_0$ (0). At about 7 V we reach a saturation in the effect, and for voltages higher than 9 V we get a non-reversible deformation, i.e., with a very long recovery time compared with the measured (~50 ms) response time of our device with ac voltage.

The second interesting feature is the dispersive behavior already pointed out for a different class of cholesterics;[3] this makes possible some unusual

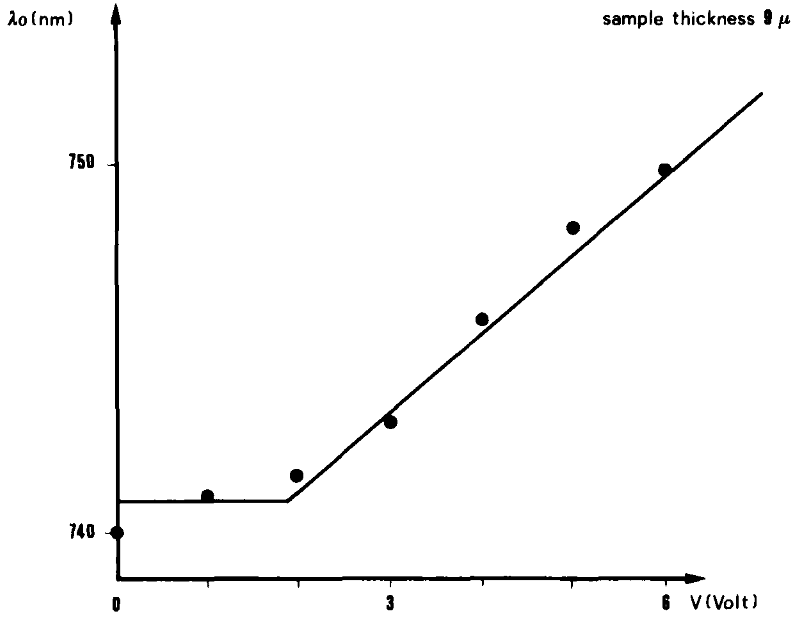

FIGURE 2 Variation of the optical rotation R-R_0 vs the voltage V applied to the cell. Three sets of data correspond to different incoming light wavelengths. Crosses: $\lambda = \lambda_0$ (0); squares $\lambda = \lambda_0 - 40$ nm; dots: $\lambda_0 = \lambda_0 - 80$ nm.

applications. In fact, we observe that the effect is strongly dependent upon the wavelength used because of the rotatory dispersion. When the wavelength is close to the reflection peak at zero field, we get a strong variation as described before, while the effect becomes smaller and smaller on increasing the difference $\lambda - \lambda_0$ (0). In figure 2 we see, that one gets an overall variation of ~12 deg for [$\lambda - \lambda_0$ (0)] = 80 nm, and a variation of ~45 deg for [$\lambda - \lambda$ (0)] = 0, when the voltage is varied from 0 V to 6 V.

We would like to stress the main features of such a device: low voltage threshold to obtain a suitable change of optical polarization, high sensitivity to the applied voltage, and high wavelength selectivity.

This last peculiar feature, not present in other liquid crystal devices, could give rise to particular applications taking into account that an optimum thickness should be chosen in order to get the maximum extinction ratio between two crossed polarizers with the maximum contrast for some particular wavelengths.

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