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Optical and Electrical Properties of Liquid Crystal Mixtures

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§1. Liquid crystals have lately attracted attention as materials for display devices. When two or more species of liquid crystals are mixed together, the expansion of the temperature range taking the mesophase becomes feasible and some characteristics which cannot be found in single species of the liquid crystal may be obtainable. In this report, the novel memory effects and other properties which have been observed in compensated mixtures of cholesteric liquid crystals are described. In addition, the helical twisting power and the compensated state in mixtures of cholesteric and nematic liquid crystals are also reported.

§2. Compensated Mixtures of Cholesteric Liquid Crystals. The nematic mesophase in which the helix pitch becomes infinite can be produced by mixing right-handed cholesteryl chloride (CC) and left-handed cholesteryl esters (e.g. cholesteryl laurate CL) in some proportion at a specific temperature T_{CN}.[1] The helix pitch in these mixtures is so long that molecules can be easily aligned by applying a relatively low electric field, where the liquid crystal becomes transparent and a dielectric constant increases to saturate. The temperature dependence of the dielectric constant ε for 62:38 by weight mixture of CC and CL is shown in Fig.1 when the molecules have been once aligned perpendicular to the electrodes by applying DC 125 V and then removed at 25°C. It is seen that ε takes the maximum value (measured at 1 kHz and 100 kHz) or the minimum value (measured at 1 MHz) at temperatures around T_{CN}. In this state, the liquid crystal molecules are aligned perpendicular to the electrode glasses (taking a homoeotropic texture) and we call this phenomenon the self-orientation (or memory) effect. If the electric field has not been applied to the cell, such a phenomenon cannot be observed (dashed curves in Fig.1). This effect depends upon the surface conditions of the electrode glasses and the intensity of the applied field. The acid-treated SnO_2-coated glasses are suitable.

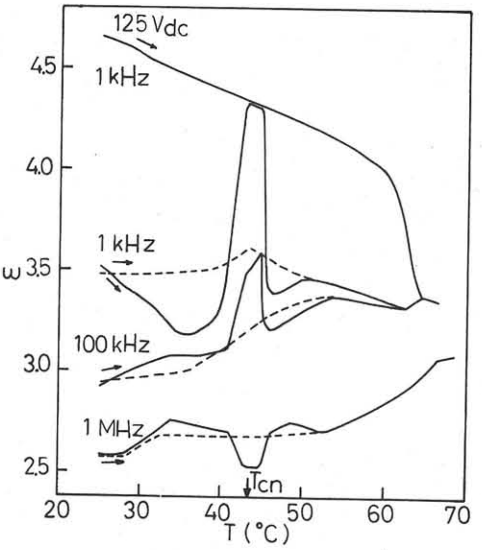

Fig.1 Dielectric constant vs. temperature. CC:CL=62:38. The sample thickness is ~50μ. Solid curves: DC 125 V was once applied and then reduced to 0 V at 25°C.

The relationship between the extent of the self-orientation effect and the intensity of the applied electric field is shown in Fig.2. Optical transmission properties are shown in Fig.3. In the memory state, the liquid crystal cell becomes transparent to the same level of an isotropic state at temperatures around T_{CN}. This memory can be erased by heating up to the isotropic state. The self-orientation effect seems to occur in the temperature range where the helix pitch is larger than the sample thickness. The phase transition from the homoeotropic to the planar texture has been observed by applying a high frequency electric field. The critical frequency depends upon the sample temperature and it varies from 3 kHz to 500 kHz as the temperature rises from 17°C to 50°C. These phenomena in compensated mixtures will be discussed based on the orientation effects or rotations around the long or short axis of the liquid crystal molecules.

§3. Mixtures of Cholesteric and Nematic Liquid Crystals. Nematic liquid crystals can be transformed into the cholesteric mesophase by adding a small amount of optically active materials (e.g. cholesteric substance) and the inverse of the helix pitch is proportional to the concentration in the low concentration region. The helical twisting power for mixtures of cholesteric liquid crystals and nematic EBBA is shown in Fig.4. Nematic EBBA seems to have the left-handed helical twisting power when they coexist with the cholesteric liquid crystals. The compensated state which is similar to the compensated mixtures of CC and CL is also produced by mixing CC and nematic EBBA or MBBA. The self-orientation effect is also observed in these mixtures, but it is weaker in the mixtures of CC and EBBA.

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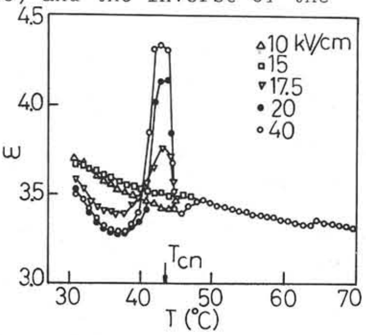

Fig.2 Relationship between the self-orientation effect and the intensity of the applied electric field.

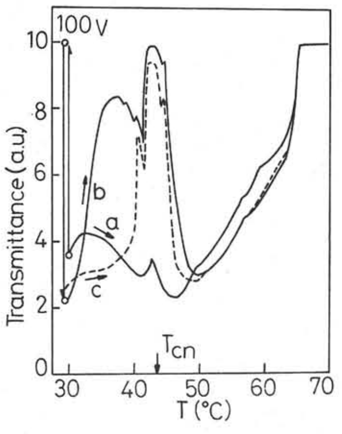

Fig.3 Optical transmittance vs. temperature. a):the voltage was not applied, b):100V was applied at 30°C, c):after several heat-cool cycles.

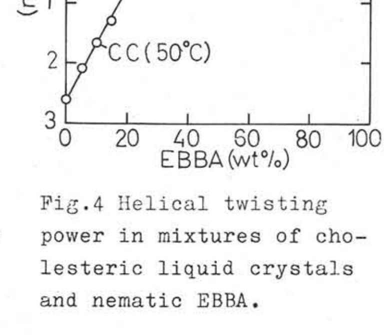

Fig.4 Helical twisting power in mixtures of cholesteric liquid crystals and nematic EBBA.

1) S.Sato and M.Wada, Japan. J. Appl. Phys. 10 (1971) 1106.