SHORT COMMUNICATIONS

On Electro-optic Effect in Lyotropic Liquid Crystals

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Some semitransparent lyotropic liquid crystals become turbid at once on application of an electrical potential and recover rapidly on removal of the potential. This phenomenon, found at first by Winsor[1] with the aqueous solutions of ionic surfactants of alkyl sulfate type, was attributed to the alignment of a randomly oriented liquid crystal by the electrical field. We have found a similar electro-optic effect in some lyotropic liquid crystals of ternary systems composed of ionic surfactant-amphiphile-water[2].

The systems examined were I, Na caprylate-caprylic acid (or decanol)-water, II, K caprylate-decanol-water, and III, cetyltrimethylammonium bromide-hexanol-water. The samples contained in a narrow-bore glass tube like a salt bridge between two electrodes were visually observed. A DC potential of about 100 V/cm was applied between two electrodes as a pulse of the order of 10 msec. Though a current of several milliamperes passed through the samples, the short time was sufficient for observing the turbidity preventing the sample from undue heating. The electro-optic effect was examined for all regions of the phase diagram.

According to Mandell and Ekwall,[3] there are structurally different liquid crystalline phases designated B, C, D, E, and F in the ternary systems I, II, and III. We found that the regions exhibiting the electro-optic effect were confined to phase B (*e.g.* 9.0% KC_8, 9.0% C_8-acid, and 82% H_2O) for system I, phases B (*e.g.* 8.6% KC_8, 9.3% decanol, and 82.1% H_2O) and C (*e.g.* 20.6% KC_8, 24.4% decanol, and 55.0% H_2O) for system II, and a part[4] of water-rich region of phase D (*e.g.* 7.6% CTAB, 5.0% hexanol, and 87.4% H_2O) for system III. Turbidity was produced only in phase B also when the alcohol in the systems was replaced by heptanol or octanol. This shows that the effect is specific for such types of liquid crystal. Phase B is smectic and has a lamellar structure comprising parallel layers of amphiphilic ions and molecules with interlayer water. Fontel *et al.*[5] considered from X-ray and other data that, in phase B, the stability of the double layers is possibly so low that they are easily divided into smaller fractions of varying size. Such a labile structure also might be associated with electro-optic effect.

Thin films of the samples in these phases were examined under a microscope between crossed Nichols. They showed weak birefringence with a woven texture. On application of a continuous potential (about 1.5 sec) of 50 V/cm to opposite edges of the film, it became turbid and the microscopic texture changed rapidly from woven to granular. At the same time the field of view as a whole darkened, showing a decrease of birefringence. This could be accounted for by assuming that the structure of liquid crystal is disrupted in part, probably by the shear induced in the liquid crystal by ionic migration, and that the fractions of liquid crystal thus produced disperse as large micelles in the medium and act as light-scattering centers.

Electro-optical turbidity effect has been also found in thin layers of some thermotropic liquid crystals of nematic class. Heilmeier *et al.*[6] attributed this effect to the orientation fluctuation produced by disruptive effects of ions in transit through the aligned nematic medium. In contrast to this case, the turbidity effect in lyotropic liquid crystals might be due to density fluctuation.

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1) P. A. Winsor, *J. Colloid Sci.*, **10**, 101 (1955).

2) Winsor stated in his recent review that the Na caprylate-decanol-water system showed the electro-optic effect in a composition in region B (*Chem. Rev.*, **68**, 1 (1968)).

3) L. Mandell and P. Ekwall, Proc. Intern. Congr. Surface Active Substances 4th Brussels, Vol. 2, 659 (1964).

4) This region also may be phase B, since the microscopic texture is similar to that observed for phase B in system I or II.

5) K. Fontel, L. Mandell, H. Lehtinen, and P. Ekwall, *Acta Polytech. Scand. ch.*, **74**, 111 (1968).

6) G. H. Heilmeier, L. A. Zanoni, and L. A. Barton, *Proc. IEEE.*, **56**, 1162 (1968).