Molecular Crystals and Liquid Crystals
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/gmcl16

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Version of record first published: 21 Mar 2007.

To cite this article: P. F. Waters & T. Sarada (1974): Measurement of the Bulk Refractive Indices of Cholesteric Mesophases, Molecular Crystals and Liquid Crystals, 25:1-2, 1-3

To link to this article: http://dx.doi.org/10.1080/15421407408083399

Mol. Cryst. Liq. Cryst., 1974, Vol. 25, pp. 1-3

Printed in Dordrecht, Holland

Measurement of the Bulk Refractive Indices of Cholesteric Mesophases

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(Received July 12, 1973)

An improved method for determining the bulk refractive indices of mesophases by using a polarizer at the ocular of an Abbe refractometer is presented.

INTRODUCTION

Several methods have been used to measure the bulk refractive indices of mesophases. Chatelain[1] and Jeppesen and Hughes[2] determined the refractive indices of liquid crystals with the Newton's rings technique. Kopf[3] used hollow prisms and the path of minimum deviation to measure the indices. Chatelain and Pellet[4] measured the refractive indices of nematic systems with a prismmeter and Dreher, Meier, and Saupe[5] used a refractometer to determine the refractive indices of cholesteric mesophases.

The precision of the measurement of the refractive indices of mesophases is improved by reading the values through a property-oriented polarizer placed over the ocular of an Abbe refractometer. This procedure also allows one to assign the refractive indices unequivocally.

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† Fellow of the Epworth Fund, 1968–1972.

This work was supported in part with an equipment grant from the Camille and Henry Dreyfus Foundation, Inc.

EXPERIMENTAL SECTION

Materials

Cholesteryl oleyl carbonate, cholesteryl 2-(2 ethoxy ethoxy) ethyl carbonate and cholesteryl erucate were obtained from the Eastman Kodak Co. Mixtures were compounded to give cholesteric mesophases which were stable near 13°C.

Procedure

The glass prism faces of a Bausch and Lomb Model 3L Abbe refractometer are rubbed several times with lens paper along their lengths. A few drops of a given cholesteric mixture are then spread with a teflon spatula along the length of the lower prism. The spreading motion is repeated several times. These operations help to align the layers of the mesophase parallel with the prism faces. The stress applied when the upper prism is clamped in place completes the alignment. A section of Polaroid HN-sheet is attatched to the ocular with its transmission axis aligned left to right and the refractive index of the ordinary ray, n_0, is read. The transmission axis is turned through 90° and the index of the extraordinary ray, n_e, is measured.

The measurements may be made with two Polaroid HN-sheets, with one used as described and the other being placed between the light source and the illuminating prism. The definition of the boundaries is improved even further with this arrangement. While the data reported here were recorded with the Amici prisms intact in the instrument, it is possible to remove them and use the refractometer with a monochrometer to obtain the refractive indices at any wavelength in the visible region.

RESULTS AND DISCUSSION

With a plane-textured cholesteric mesophase aligned in the refractometer as described, the optic axis of a continuous single-domain system is perpendicular to the prism faces. Light entering the instrument at grazing incidence is perpendicular to the optic axis. The two rays characterized by n_e and n_0 exhibit electric vibrations in the principal plane containing the optic axis and in the molecular planes comprising the twisted layers of the mesophase,[6] respectively. From the optics of the refractometer it is apparent that the placing of a polarizer on the ocular with its transmission axis oriented top to bottom allows n_e to be read while causing the boundary corresponding to n_0 to disappear. With this orientation the higher index boundary disappeared in all samples of cholesteric mesophases examined. When the polarizer was turned through 90° the lower

index boundary disappeared and the higher index one was sharpened considerably.

The results for five cholesteric mesophases are given in Table I.

The data confirm that these systems in bulk exhibit the properties of uniaxial negative crystals.[7] The results agree with observations made with a polarizing microscope. Because the incident light is perpendicular to the optic axis, n_e is at its extremum value. Following de Vries[8] model of the cholesteric mesophase, n_0 represents the average value of the refractive indices in the molecular planes.

TABLE I

Refractive indices of some cholesteric mixtures for the sodium D line

Mixture composition weight ratios[a]	Temperature °C	Ordinary index n_0	Extraordinary index, n_e	Birefringence $n_e - n_0$	Dispersion value
1) OCC: EE:: 1.1105 :1	12.5	1.51240	1.49675	−0.01565	18.50
2) OCC: EE:: 1.1665 :1	13.	1.51040	1.49490	−0.01550	18.20
3) OCC: EE:: .9851 :1	13.	1.51110	1.49540	−0.01570	18.50
4) EE: E:: 1.0293 :1	12.5	1.51170	1.49760	−0.01410	17.90
5) EE: OCC:E:: 2.3115: 2.5665 :1	12.5	1.51310	1.49610	−0.01700	18.00

[a] OCC is Cholesteryl Oleyl Carbonate
EE is Cholestryl 2-(2-ethoxy ethoxy) ethyl carbonate.
E is Cholesteryl Erucate.

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