

Application of Modified Interference Wedge Method in Measurements of Indices of Refraction and Birefringence of Nematic Liquid Crystals

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Wedge cell filled with a homogeneously oriented nematic liquid crystal was exploited as an interference wedge to measuring indices of refraction. Interference fringes from the wedge were observed in polarised light in reflection or transmission mode of a polarisation microscope to determining ordinary and extraordinary indices of refraction or birefringence (i.e. anisotropy of both indices). The interference fringes close to wedge apex were uniform and could be well described in two-beam interference approximation. The refractive indices were computed with using simple formulae involving only distances between subsequent fringes in a cell filled with the liquid crystal and an empty reference cell. Several new highly-birefringent nematic mixtures produced in the Military University of Technology were investigated. The 6CHBT nematic was used as the reference material.

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1. Introduction

Light beam travelling through a uniaxial crystal is split into ordinary and extraordinary rays characterised by ordinary and extraordinary refractive indices. A plane wave of properly polarised light can propagate as only one of this rays. A homogeneously oriented nematic liquid crystal is an uniaxial crystal with optical axis of direction pointed by uniform nematic director. An ordinary ray of electric field vector perpendicular to the axis or an extraordinary ray of electric field vector parallel to the axis can be formed with using a polariser of eigenvector in corresponding direction. To determining refractive indices of liquid crystals, the same methods as for bulk crystals can be applied. The Haller method exploiting interference wedge, described in [1] and used in [2–5] was modified to measuring refractive indices of nematics.

A wedge cell (Fig. 1) were made of glass plates coated with transparent indium–tin oxide electrodes and polyimide films rubbed in direction parallel to wedge apex. The rectangular glass covers of size 22 mm per 35 mm were connected along short edge on one side and with the spacer s of thickness about 0.12 mm on the other side. The cell was filled with a nematic liquid crystal. The rubbing enforced homogeneous orientation of the nematic with uniform director field in the direction parallel to both the wedge apex and plane surfaces of covers. Such cell was an optical wedge made of uniaxial crystal.

The interference fringes appear in polarised light transmitted through or reflected by the wedge cell. Each fringe

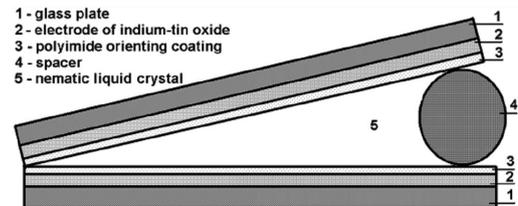


Fig. 1. Scheme of a wedge cell (side view).

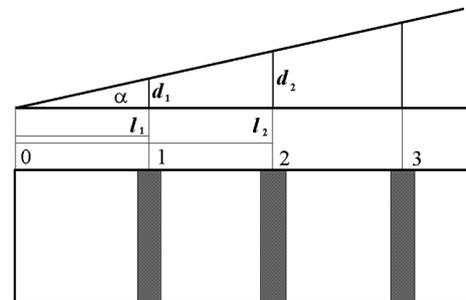


Fig. 2. Schematic sketch of interference fringes in a nematic wedge cell observed in polarised light (side view and front view).

corresponds to phase shift equal to an integer multiplicity of π between the rays reflected from the surface of one and other cover; to describe well the fringes close to wedge apex it suffices to account for two-beam interference approximation. They can be observed in microscope.

In the reflection or transmission mode, light incident normally is polarised perpendicular or parallel to the wedge apex, which makes possible to determine ordinary or extraordinary index of refraction accordingly (Fig. 2).

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TABLE

Results of measurements for nematic liquid crystals under study obtained with using wedge cell method and with using an Abbé refractometer to compare.

Symbol of substance	Wedge cell method			Abbé refractometer		
	Δn	n_e	n_o	Δn	n_e	n_o
6CHBT	0.157	1.675	1.518	0.157	1.677	1.520
1816	0.220	1.721	1.501	0.221	1.724	1.503
Mix1	0.235	1.728	1.493			
Mix2	0.251	1.784	1.533			
Mix5	0.238	1.758	1.520			
Mix6	0.234	1.693	1.459			
Mix7	0.242	1.762	1.520			
Mix8	0.246	1.723	1.477			

4. Discussion

The described above method for determining refractive indices of liquid crystals can be effectively used only when the interference fringes are equidistant. This is the case when the reflection coefficient at the limit of cell cover and liquid crystal is small [5] and the two-beam approximation for describing interference is accurate. Then in general at least a few tens of fringes close to wedge cell apex are equidistant in good approximation and only up to about twenty should be exploited in measurements. In the birefringent system all fringes observed in transmitted light are then equidistant [7]. For successful measurements the following conditions should be preserved:

- The spacer should be chosen of size enabling rather narrow fringes, since for broad fringes the distance between them is determined less precisely.
- The interference wedge cell should be constructed of glass plates with refractive index sufficient to fulfilling Fresnel conditions for reflection from limits of liquid crystal [6, 8].
- The cell for measurements can be also cylindrical or spherical [11–13]; then formulae (6) must be modified.
- Highly monochromatic light is strongly recommended for stable measurements. In this work yellow light from sodium lamp was applied. Coherent laser light is worse due to coherence noise disturbing measurements.
- The determination of birefringence (Δn) in dependence on temperature is enough to estimating the parameter of orientation order of liquid crystal [11–13].

More accurate multi-beam approximation of interference together with methods for determining refractive

indices, exploiting distances between interference fringes, was described in [5]. The determination of birefringence is less precise than in the case of present method.

5. Conclusion

The simple method was described for determining ordinary and extraordinary refractive indices and birefringence of uniaxial liquid crystals from only distances between interference fringes observed in an empty and then filled wedge cell. The method was verified successfully in measurements of parameters of new liquid crystalline mixtures.

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