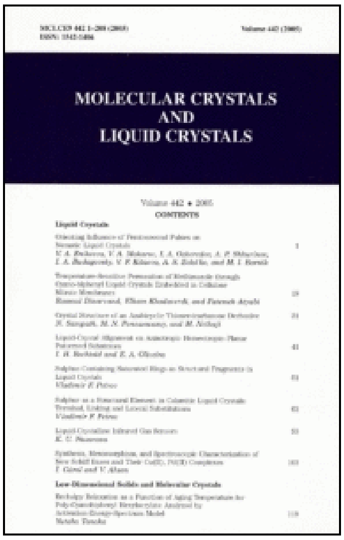

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SCHLIEREN TEXTURES IN BIAXIAL NEMATIC LIQUID CRYSTALS[1]

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Abstract The optical textures exhibited by the mesophases of three compounds, all of which are reported to show the biaxial nematic phase, have been examined. The textures are of the usual nematic schlieren type, except that they consist entirely of disclinations of strength $|s| = ½$. It is suggested that the absence of disclinations of unit strength is diagnostic of biaxiality.

INTRODUCTION

Our first studies on the biaxial nematic liquid crystal (N_b) were carried out in Bangalore nearly ten years ago[2,3] following a suggestion by one of us[4] that a convenient way of obtaining the N_b phase in a low molecular weight thermotropic system would be to prepare a mesogen that combines the features of the rod and the disk. We investigated the copper complex [1,2,4] *bis*[1-p-n- decyl biphenyl) 3- (p-ethoxy phenyl) propane- 1,3- dionato] copper(II), hereafter referred to as complex **I** (Figure 1), which was synthesized specially for the study by B.K. Sadashiva and S. Ramesha[2]. It is an `elongated' version of the discotic copper complex, *bis* [(p-n-decylbenzoyl) methanato] copper(II), reported by Giroud-Godquin and Billard.[5] The mesophase of complex **I** showed nematic type of schlieren textures, while homeotropically aligned samples showed conoscopic patterns typical of a biaxial medium.[3,6] Magnetically aligned samples gave X-ray patterns with three pairs of diffuse (liquid-like) peaks, one pair in the meridional direction and two pairs in the equatorial direction, as would be expected from an orthorhombic fluid.[7]

I

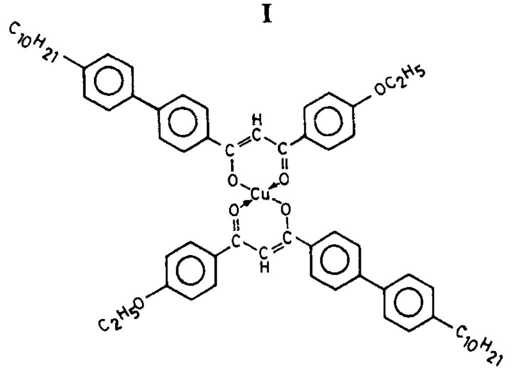


FIGURE 1 Structural formula of complex **I**

The possible molecular shapes that might be expected to show the N_b phase – the rod-disk-rod, disk-rod-disk, disk-rod and similar types of structures – have been discussed, and indeed, about dozen compounds have been synthesized[8,9,10] which apparently exhibit the N_b phase, as inferred by optical (conoscopic) and X-ray studies.

However, it should be pointed out that while the X-ray evidence presented in references 7 and 8 lend support to the optical observations, they do not provide independent, unambiguous proof of long range biaxial order. The additional peaks in the X-ray photographs could well arise from cybotactic groups or smectic-like short range order. Thus, despite the optical evidence, some doubts remain as to whether these compounds do in fact exhibit true long range biaxial nematic order. We therefore decided to undertake a more systematic study in an attempt to establish the biaxiality conclusively. In this paper we describe our optical observations which appear to support the biaxial nature of the mesophases. X-ray studies will be taken up shortly and will be reported in a later paper.

SCHLIEREN TEXTURES

As remarked earlier, the optical textures of the mesophase of complex **I** (sandwiched between two clean untreated glass plates) resembled the usual nematic schlieren patterns, but on closer examination it was noticed that they consisted entirely of disclinations of strength $|s| = ½$ (i.e. two-brush disclinations). An example is given in Figure 2. (See also figure 1 of ref. 7 and figure 2 of ref. 12). We then studied the

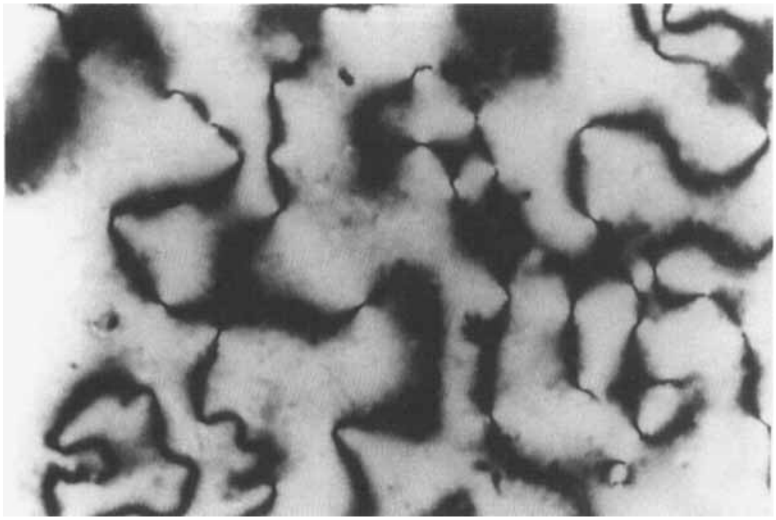
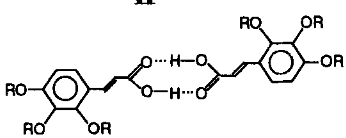


FIGURE 2 Schlieren texture exhibited by the nematic phase of complex **I**. Note that only two-brush disclinations, $|s| = \frac{1}{2}$, are seen.[11]

II

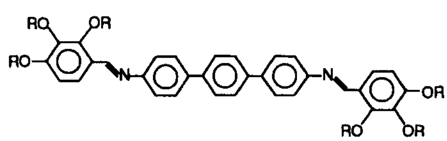


$R = C_6H_{13}$

Crystal → N_b → Isotropic
51.2°C 59.6°C

FIGURE 3 Structural formula of **II**[8].

III



$R = C_{12}H_{25}$

Crystal → N_b → Isotropic
83°C 117°C

FIGURE 4 Structural formula of **III**[13].

mesophase textures of two other compounds, viz., 2,3,4 - trihexyloxy cinnamic acid dimer[8] (**II**; Figure 3) and N, N′- *bis* (2,3,4 - trido decyloxy benzylidine) p-terphenyl diamine[13] (**III**; Figure 4). Photographs of their textures are shown in Figures 5 and 6 and again as can be seen they consist of just two-brush disclinations. On the other hand, it is well known that in the ordinary uniaxial nematic, both $|s| = \frac{1}{2}$ and 1 are present (Figure 7).

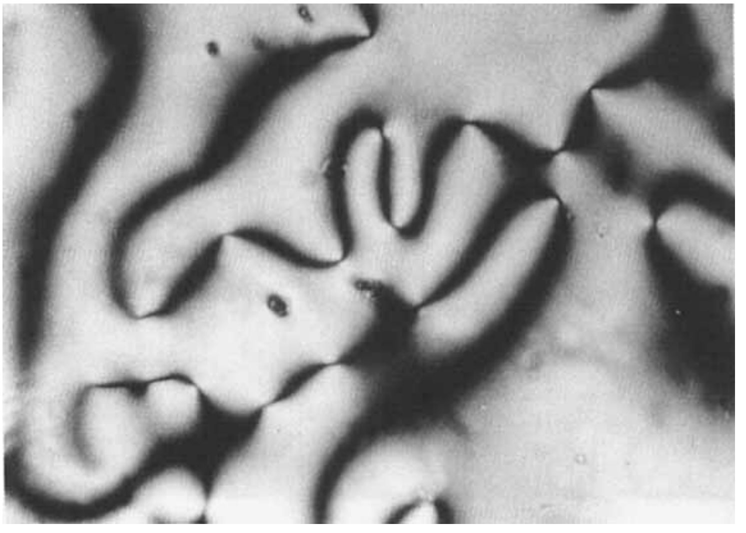


FIGURE 5 Schlieren texture exhibited by the nematic phase of **II**. Note that only two-brush disclinations, $|s| = \frac{1}{2}$, are seen. See Color Plate I.

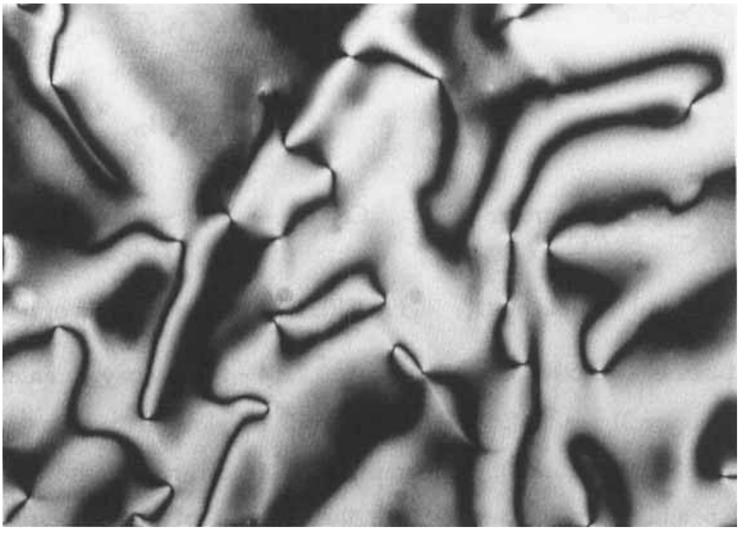


FIGURE 6 Schlieren texture exhibited by the nematic phase of **III**. Note that only two-brush disclinations, $|s| = \frac{1}{2}$, are seen. See Color Plate II.

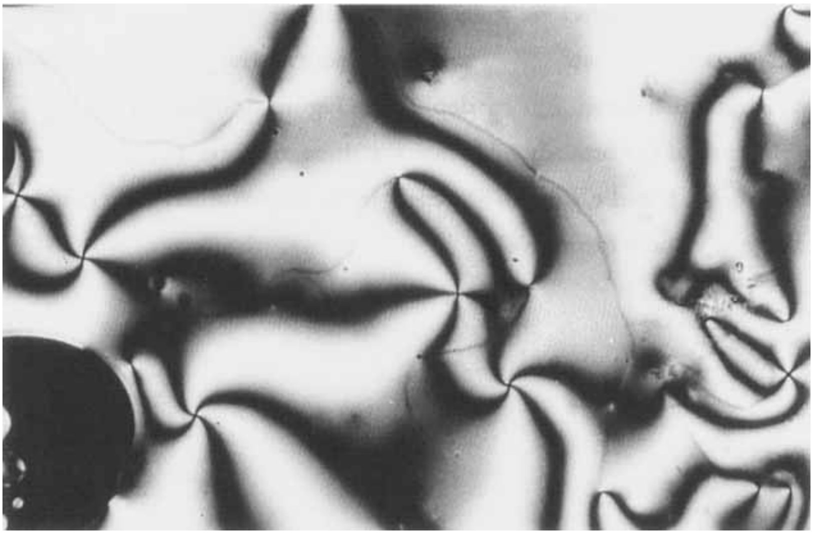
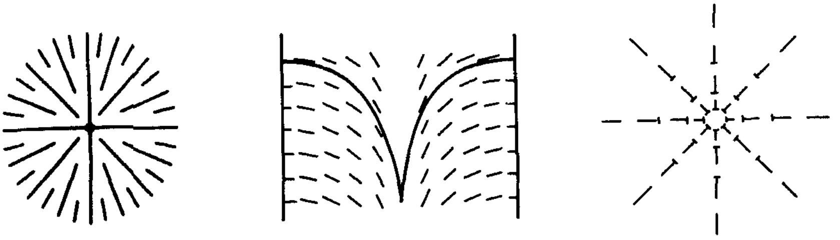


FIGURE 7 Schlieren texture exhibited by the ordinary uniaxial nematic phase of Octyl benzoic acid. Note that both two- and four-brush disclinations, $|s| = \frac{1}{2}$ and 1 respectively, are seen. See Color Plate III.

DISCUSSION

The director field around a disclination of strength s=1, c=0, for the classical uniaxial nematic is shown in Figure 8(i). Experiments[14,15] have confirmed that the singularity



(i) (ii) (iii)

FIGURE 8(i) Director field around a disclination of unit strength, s=1, c=0, for a uniaxial nematic according to the planar model. Director `escape' at the centre of the disclination: (ii) the sample is contained in a capillary; the alignment is homeotropic at the wall and changes by 90° from wall to axis. (iii) Projection of the structure on a plane normal to the capillary axis. Nails signify that the director is tilted with respect to the plane of the paper.

at the origin of this defect as given by the planar model can be avoided by a nonsingular continuous structure of lower energy. The director orientation now escapes' in the third dimension as depicted in Figure 8(ii) and (iii) for s = 1.

In the case of the orthorhombic nematic there are three mutually perpendicular director vectors **a**, **b** and **c**, (Figure 9) which in the unperturbed state may be taken to be parallel to x, y and z respectively.

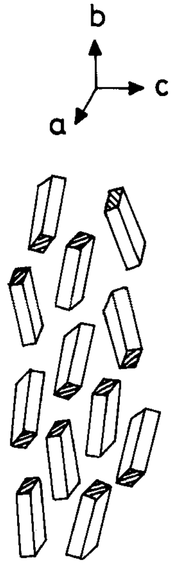


FIGURE 9 Schematic representation of the molecular order in an orthorhombic biaxial nematic.

Figure 10(i) illustrates the structure of a disclination of strength s=1, the disclination line being parallel to y. If one of the directors is allowed to escape in the third dimension, it automatically leads to another planar configuration (Figure 10(ii)). Hence, a singularity at the origin continues to exist and the escape mechanism is unable to remove it.[16,17]

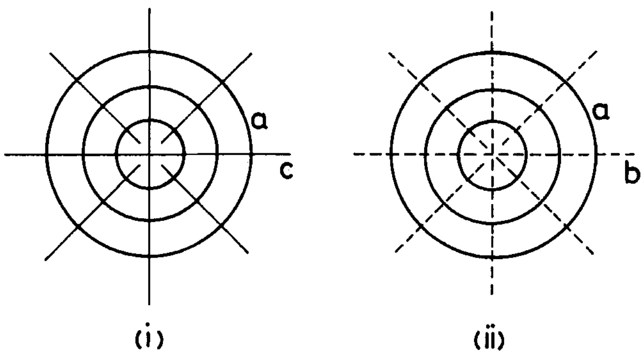


FIGURE 10 (i) Director field for |s|=1 disclination in an orthorhombic biaxial nematic. Concentric circles represent the *a*-director and radial lines the *c*-director (ii) The structure that results when the *c*-director in (i) escapes by a rotation of $\pi/2$ about the *a*-axis. The dashed lines represent the *b*-director. Notice that the singularity continues to exist at the origin.

This appears to be a plausible reason why |s| = ½ is favoured. Thus the absence of |s| = 1 is probably diagnostic of biaxiality. We propose to take up X-ray studies to confirm these conclusions.

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