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NEMATIC DROPLETS WITH A NEW STRUCTURE

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Abstract. We have found nematic droplets with a new structure, suspended in the isotropic phase of some mixtures of a nematogen with a nonmesomorphic compound. The molecules are oriented at an angle of $\sim 45^o$ to the nematic-isotropic interface. This leads to an arrangement of the molecules in the droplets such that there are two point defects at the poles and an equatorial line defect.

INTRODUCTION

The structures of nematic droplets floating in an isotropic liquid medium have been studied earlier both theoretically[1] and experimentally.[2-5] Depending on the molecular alignment at the interface, two different configurations have been found. If the molecules are aligned in a direction perpendicular to the interface, the one-elastic constant ($K_{11} = K_{22} = K_{33} = K$) approximation would lead to a spherically symmetric *star* configuration of the director[1] as shown in a section in fig. 1a. This configuration would imply a disclination point of strength +1 at the centre of the droplet. Actually, in some cases observations indicate a more complicated structure,[5-7] which is a consequence of elastic anisotropy, the twist elastic constant generally having the lowest value.

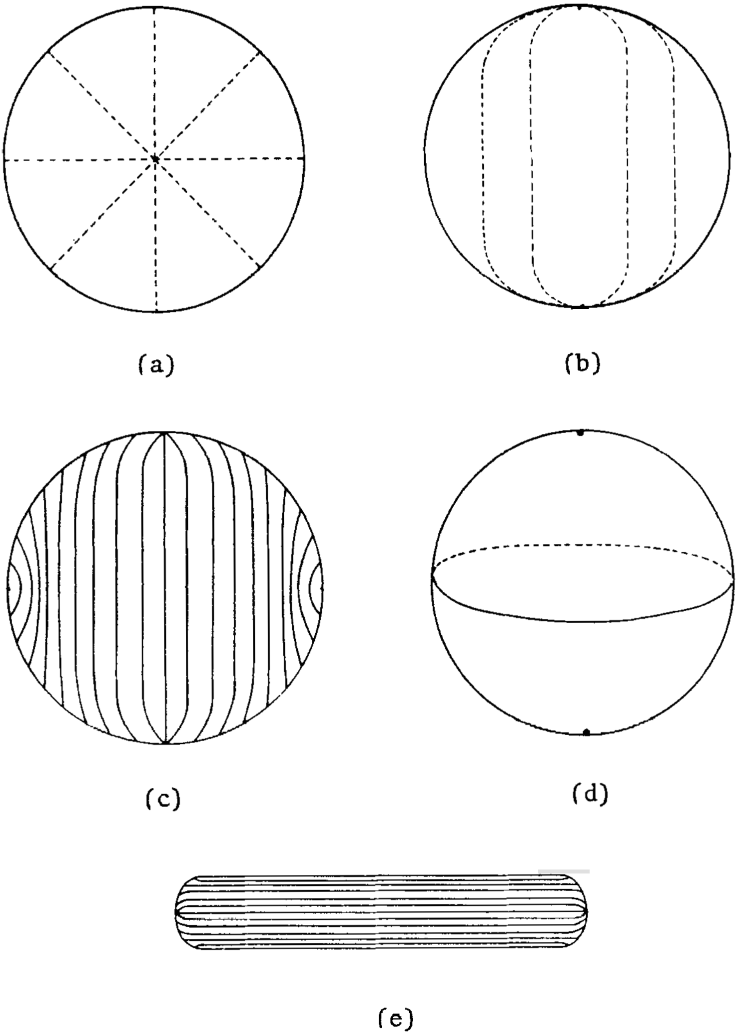


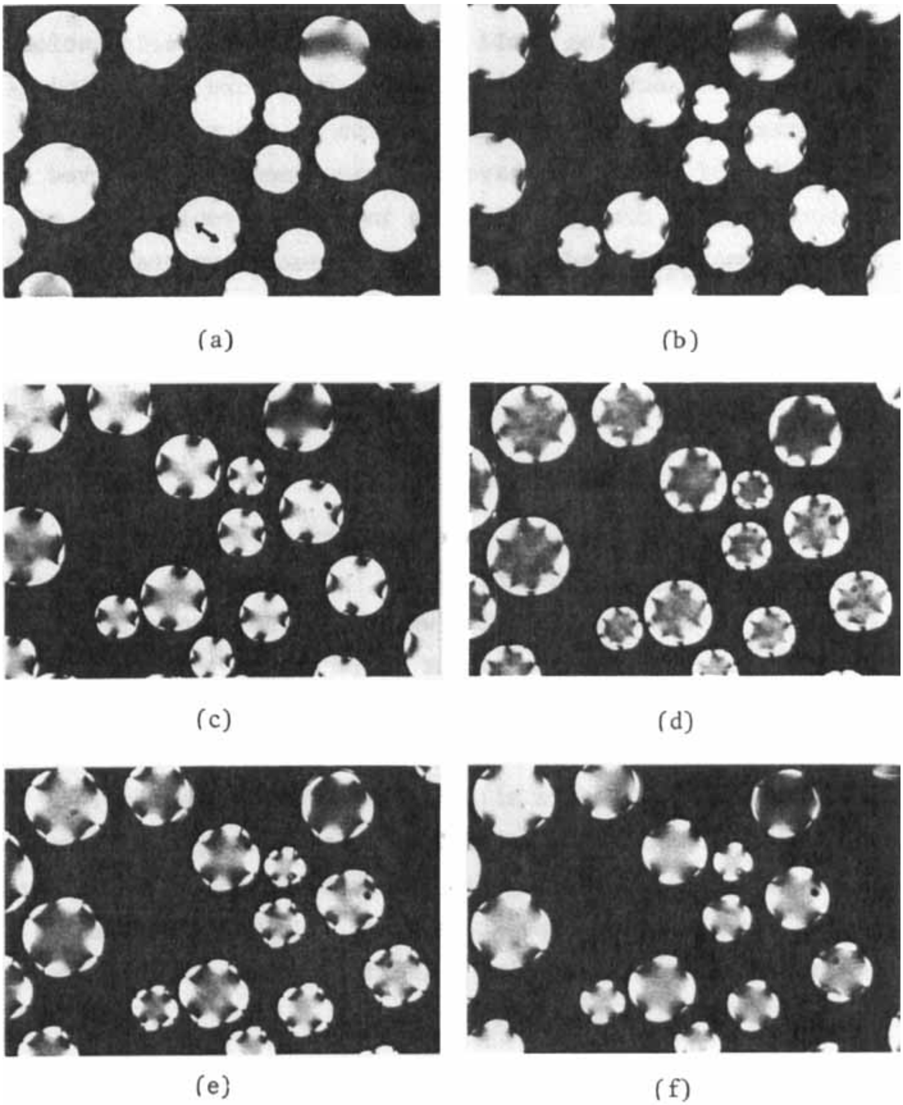
FIG. 1. Schematic diagrams of the director orientation patterns in a principal section of a nematic droplet with (a) normal, (b) tangential, and (c) tilted boundary conditions. The configuration shown in (c) leads to two polar point defects and an equatorial line defect as shown in (d). In (e), the director is oriented homogeneously between a slide and a cover slip, and the diagram shows the director configuration in the vertical section (containing $\vec{n}$) when the droplet is surrounded by the isotropic phase.

When the boundary condition is tangential, i.e., the molecules prefer to lie parallel to the interface, the one constant approximation would lead to a *bipolar* configuration[1] as shown in a section in fig.1b. The structure has cylindrical symmetry and has two point defects at the two poles. Both types of structures have been experimentally observed in both nematic droplets floating in the isotropic phase of the same material[2] and in emulsions of such droplets floating in a suitable liquid like glycerol.[3,5] In the present paper we report our observations on droplets with a new type of structure.

OBSERVATIONS AND DISCUSSION

The observations were made on mixtures of 4-cyanophenyl-*trans*-4'-n-pentylcyclohexane (PCH5) a low melting nematogenic compound, with n-heptylcyanide which is nonmesomorphic. The mixtures usually contained about 8% of the latter compound. As a consequence the NI transition temperature of the mixture is considerably lower than that of the pure nematogen. As a sample taken between a slide and a coverslip was cooled (in a Mettler hot stage, model FP52) nematic droplets formed and grew in size. The nematic and isotropic phases coexisted over a considerable temperature range ($\sim 10^{\circ}C$). All the observations were made using a Leitz polarizing microscope (model Ortholux II POL-BK).

In our first experiments, we cooled the sample between a slide and a coverslip, both of which had been given a coating of silicon monoxide at an oblique angle to get a homogeneous alignment. The temperature was adjusted to get a few nematic droplets, surrounded by the isotropic phase of the mixture. Figs.2a-f show the dark brush patterns seen



(a) (b) (c) (d) (e) (f)

FIG.2: Changes in the dark brushes exhibited by the droplets as the azimuth of the pair of crossed polarizer is changed in an anticlockwise direction. (a) -30°, (b) -20°, (c) -10°, (d) 0°, (e) +10° and (f) +20°. The angles are measured with reference to the director orientation in the central portion of the droplets, indicated by the line in photograph (a). Magnification x250.

in the droplets as the pair of crossed polarizers was rotated to various azimuth angles. It is clear that these droplets have a new structure, since one can see (apparently) 4 defects on the nematic-isotropic interface, one pair aligned along the axis of the director (in the region touching the glass plates) and the other pair normal to that direction. Further, we see from fig.2d, in which the crossed polarizers are along and normal to the director, that additional dark brushes start from the interface in the droplets at points which are $\sim 45^{\circ}$ from the director in the region touching the glass plates. This means that at the nematic-isotropic interface, the molecules are aligned at $\sim 45^{\circ}$ to the normal. As we shall see presently, this boundary condition is responsible for the structure of the droplets.

Fig.3a shows the appearance of the droplets when the glass plates have been treated to get a homeotropic alignment. The nematic-isotropic boundary looks bright, with dark lines crossing along and normal to the polarizer direction. Indeed under this condition, when two droplets merge (fig.3b-d), the region where the droplets have merged retains a bright field of view for a relatively long time ($\sim \frac{1}{2}$ minute) before the homeotropic alignment is established. Apparently, the region where the droplets have merged retains some isotropic material which slowly goes over to the nematic phase.

When observations are made on a thick sample ($\sim 500\ \mu$) *spherical* droplets form which have the aspect shown in fig.3e. They have two point defects at the poles and an equatorial line defect. When a transverse electric field is applied, the poles get aligned along the field (fig.3f).

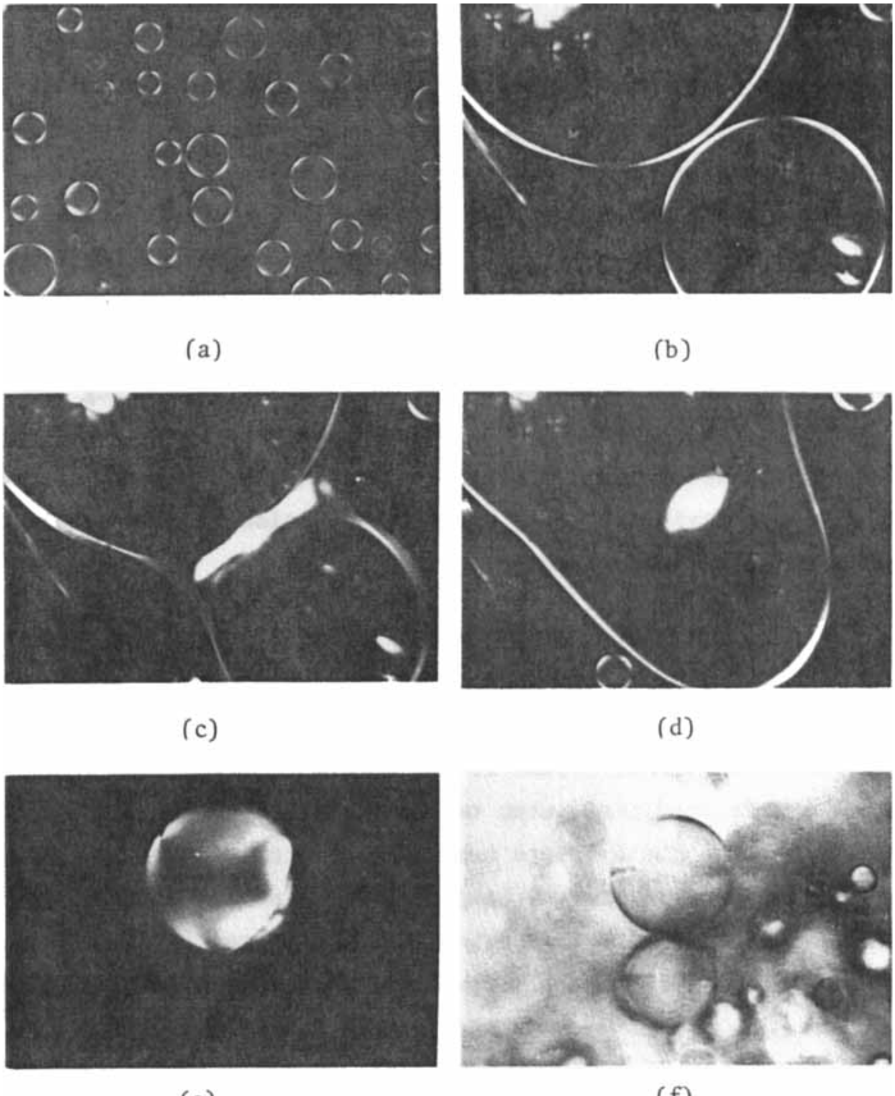


FIG.3: (a) The appearance of the droplets with homeotropic boundary conditions in the central region, viewed between crossed polarizers. (b)-(d) Successive photographs of two homeotropically aligned regions merging. Note the bright region which disappears slowly after the merger (magnification x250). (e) A spherical droplet showing one of the polar point defects and a part of the equatorial defect. (f) An electric field acting from top to bottom aligns the spherical droplets such that the poles are aligned along the field direction (Magnification: x500).

All the observations can be explained by assuming that the director pattern of the spherical droplet is as shown in a section (through the poles) in fig.1c. The droplets of figs.2a-f would then have the boundary conditions as shown in fig.1e for a principal section containing the director in the region touching the glass plates. Indeed the director configuration in these droplets would be somewhat similar to that of a thin slice of the spherical droplet containing the poles. It would then appear to have four point defects as seen in figs.2a-f. Similarly the droplet shown in 3a would correspond to a thin slice of the spherical droplet containing the equator.

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