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NETWORKS OF POINT DISCLINATIONS AT THE NEMATIC-ISOTROPIC INTERFACE

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ABSTRACT. In an earlier study, we found that in a mixture of a nematogen with a nonmesomorphic compound, the director takes an oblique orientation at the nematic-isotropic interface. In the present paper, we report observations of regular networks of a large number of disclination points on samples with a relatively large area of such an interface.

de Gennes[1] worked out the theory of the deformation of the director orientation at the free surface of a nematic sample under the action of an external magnetic field. If the surface induced orientation of the director is different from that required by the magnetic field, disclination points are expected to occur at the ~~surface~~. They are associated with weak cusps or valleys[2] and the equilibrium configuration is determined by the balance of surface, gravitational, elastic and magnetic forces. If there are a large number of such defects, they could be expected to arrange themselves in regular networks and this gives the appearance of *domains*.

Experimentally, point singularities have been found at the nematic-isotropic interface by Meyer[3] who has studied them in considerable detail. Williams has observed a few broad domains at the free surfaces of paraazoxyanisole[4] and

N-p-methoxybenzylidene-p-butylaniline[5] when a sufficiently strong horizontal magnetic field was applied across the sample. This observation has been interpreted by de Gennes[1,2] as due to the occurrence of surface disclinations. However, no regular networks appear to have been found in any study so far.

We[6] recently found that in mixtures of 4-cyanophenyl-*trans*-4'-n-pentylcyclohexane (PCH-5), a low melting nematogenic compound, with ∿10% of n-heptylcyanide which is non-mesomorphic, the director is inclined at ∿45° to the nematic-isotropic interface. This conclusion was based on our studies on a new type of structure that nematic drops exhibit in this mixture. When this mixture is spread on a slide, one sometimes obtains large areas of the nematic-isotropic interface. If the boundary condition on the glass surface favours a homogeneous or a homeotropic alignment, it is clear that the oblique director orientation at the nematic-isotropic interface does not match with the orientation in the bulk, and thus it is possible to generate a large number of surface disclination points, without the action of any external fields. Photographs shown in figure 1a-e show a collection of such point defects at the interface observed with a thoroughly cleaned glass slide. In such a case, the director gets oriented with a homeotropic alignment at the glass boundary and we clearly see regions in which the disclination points are arranged in a regular lattice. In these photographs, taken at a relatively low magnification, one can see areas with different orientations of the lattices of defects. As the pair of crossed polarizers is rotated, the appearance of the pattern changes, the bright and dark regions exchanging positions for a rotation of ∿45°. We have

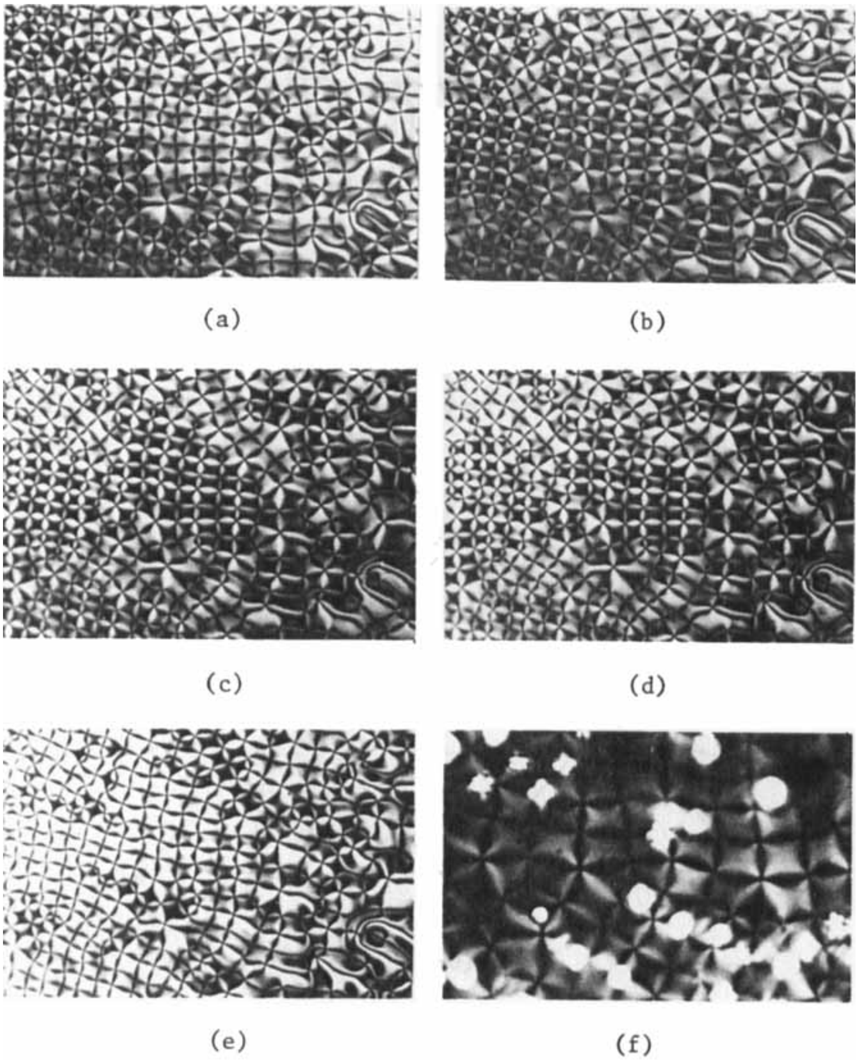

FIG.1. (a-e) An area of the nematic-isotropic interface with a large number of point disclinations. Regular networks of the defects can be seen in some parts. The crossed polarizers are rotated anticlockwise from (a) to (e). The settings are (a) 0^o, (b) 20^o, (c) 30^o, (d) 40^o and (e) 60^o. Notice that in photographs (c) and (d) the brightness of *crosses* is not uniform. Photograph (f) was taken with a thick ($\sim$1 mm) sample. Notice the nematic droplets forming in the isotropic phase. (Magnification x 125).

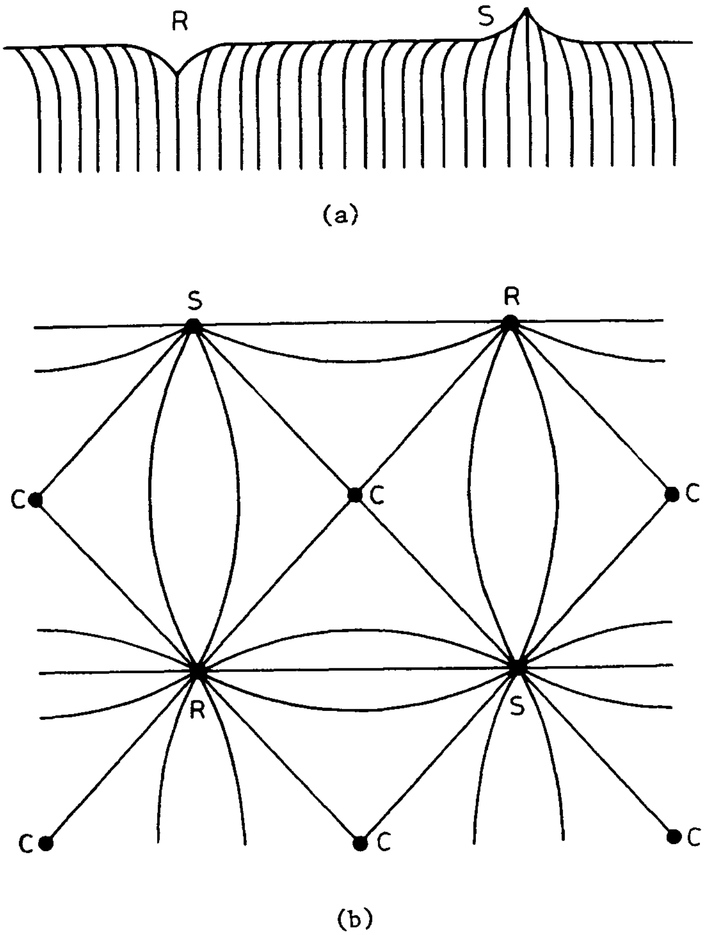

FIG.2. (a) A possible arrangement of the director close to the nematic-isotropic interface. The point defects are formed at the cusp (S) and the dip (R). Notice that the director is throughout inclined obliquely with respect to the interface. (b) A regular network of defects as visualized by de Gennes.[2] The lines are projections of the director at the interface.

drawn in fig.2a the expected arrangement of the director in a vertical section close to the NI boundary, containing both a cusp (S) and a dip (R). It is worthwhile noting that the deviation from the homeotropic alignment occurs over a relatively thin section close to the interface. Fig.2b (taken from ref.2) illustrates the 2-dimensional array of the cusps and dips on an extended interface. The lines in this diagram represent the projection of the director on the plane of the interface. A comparison of this diagram with the photographs of fig.1a-e immediately brings out the striking resemblance between the observed pattern and the one predicted by de Gennes. The existence of the nematic-isotropic interface is demonstrated by the fact that as the sample is cooled further, circular nematic droplets form in the isotropic region, against the background of the point defects (fig.1f). These droplets have a unique structure which has been discussed elesewhere.[6]

n-Heptylcyanide is a relatively volatile compound and hence tends to evaporate with time. This changes the conditions at the interface. The domain pattern also alters with time as the photographs in figures 3a-f indicate. The well formed 2d lattice (with dislocations) seen in fig.3a breaks up with time, and as more and more of n-heptyl cyanide evaporates, it degenerates to a set of linear array of connected defects (fig.3c-e) and then to a web-like arrangements as large areas become free of surface defects (fig.3f). The chain of defects in fig.3d is more clearly illustrated in the magnified print shown in fig.4a.

In conclusion, the present investigation has demonstrated for the first time the occurrence of a regular lattice of point defects at the nematic-isotropic interface. Detailed investigations on the growth and development of these defects are underway.

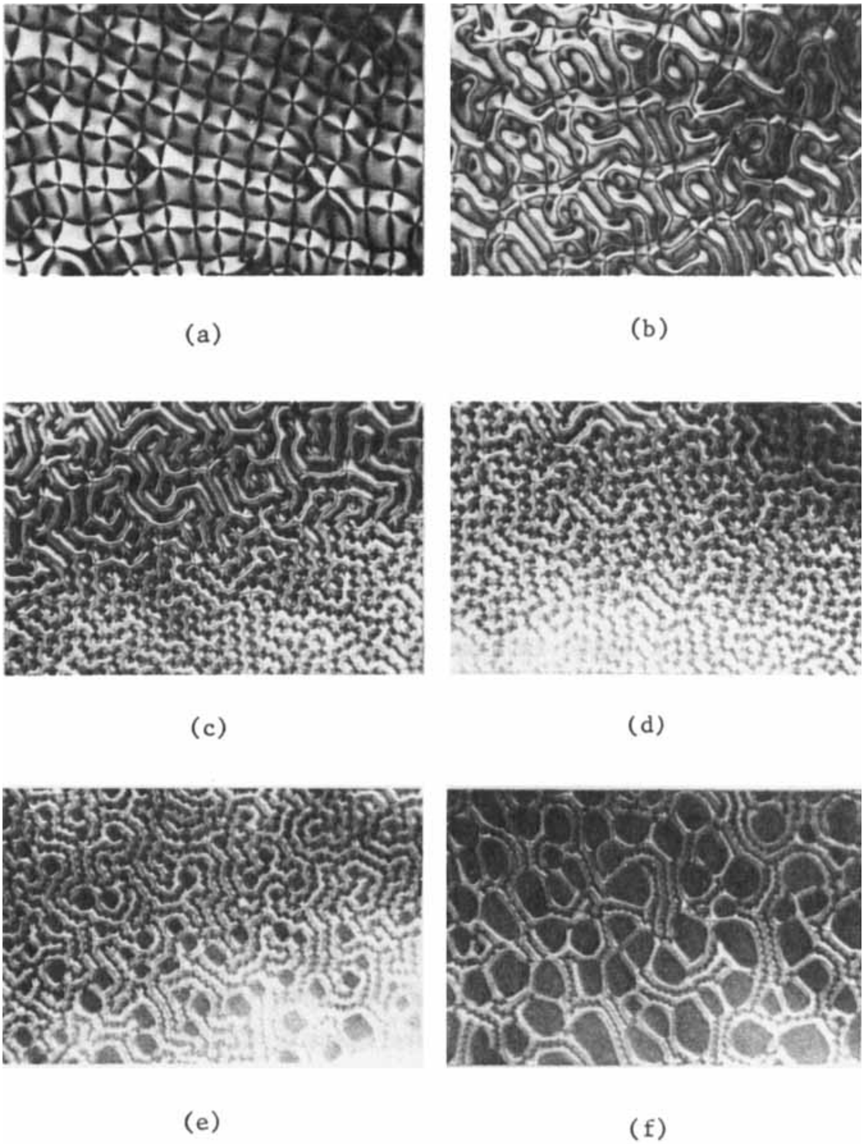

FIG.3. (a-f) Changes with time of the defect pattern at the interface of specimen as the n-heptylcyanide evaporates. (a) The pattern at the beginning. Notice an edge dislocation in the array of defects (b-f) the same area photographed as the pattern changes. (Magnification x 250).

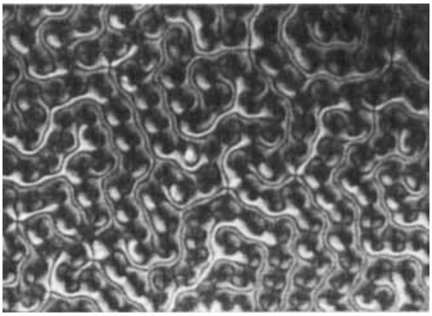

FIG.4a. A magnified print of photograph 3d. Notice the *chains* of point defects. (Magnification x 500).

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