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Liquid Crystals

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Lyomesophases formed by the dinucleoside phosphate d(GpG)

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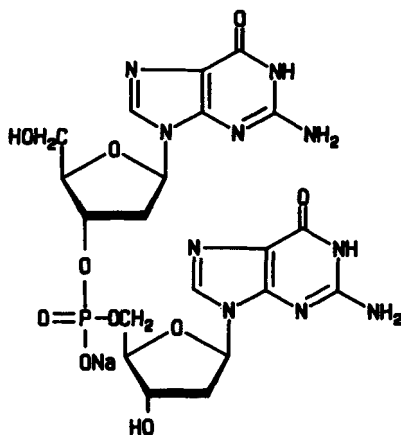
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The sodium salt of the dinucleoside phosphate d(GpG), dissolved in water, forms two mesophases which have been characterized, by optical microscopy, as being of the cholesteric (columnar chiral nematic, N*) and hexagonal (M) type.

It is known that some guanine nucleosides and nucleotides aggregate in water to form gels and fibres [1]. However, as far as we are aware, no publications on the formation of liquid crystals have previously appeared. We report that the sodium salt of the dinucleoside phosphate d(GpG) [2],



dissolved in water at room temperature, forms two mesophases.

Microscopic observation of a sample with a concentration gradient obtained by peripheral evaporation (see figure 1) shows these two phases. Dilute solutions exhibit typical cholesteric textures; it is possible to align the cholesteric axis with a magnetic field to obtain planar or fingerprint textures [4] (see figure 2); the helix is not unwound by the field. These observations indicate that the structural unit of the cholesteric assembly has a negative diamagnetic anisotropy; that is a type II cholesteric [5]. The pitch, as measured from the fingerprint texture, shows an inverse dependence on the concentration (see figure 3) over the range investigated.

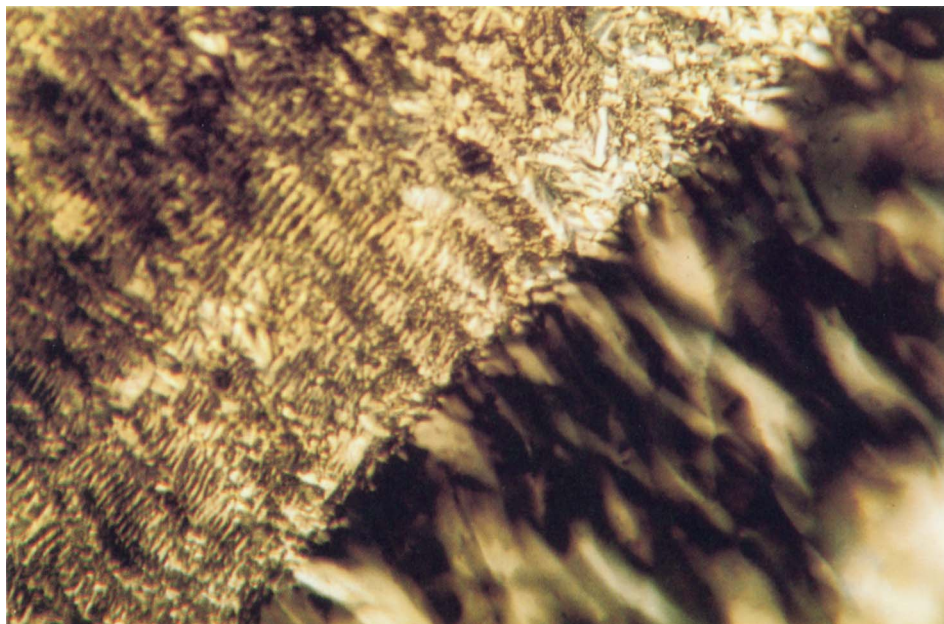


Figure 1. Textures obtained by peripheral evaporation of a solution of the d(GpG) sodium salt. The higher concentration region (top left) displays a herring-bone texture, typical of a hexagonal columnar (M) phase whilst the lower concentration region (bottom right) is the cholesteric (chiral nematic, N*) phase (crossed polars, 250 \times).

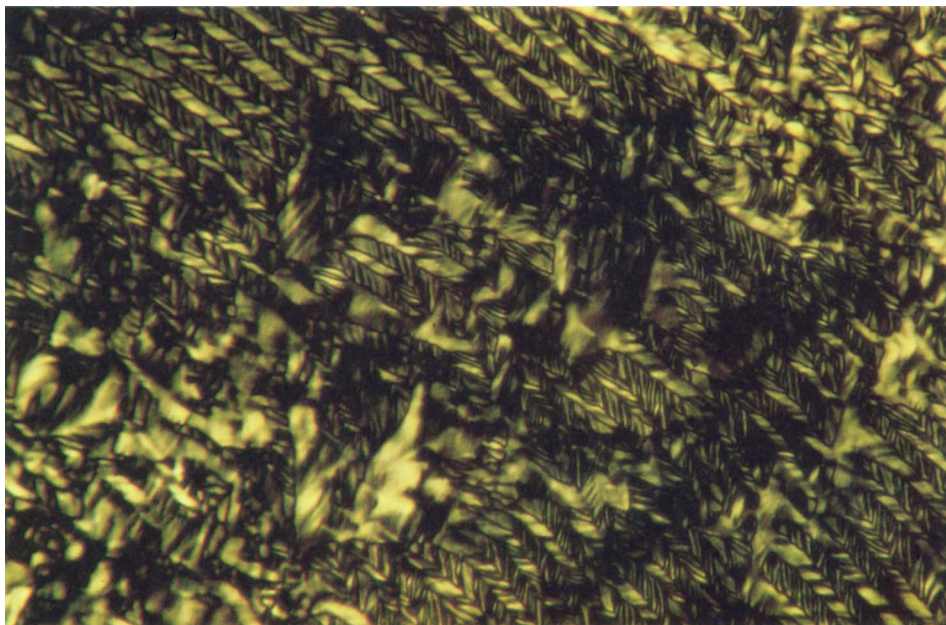
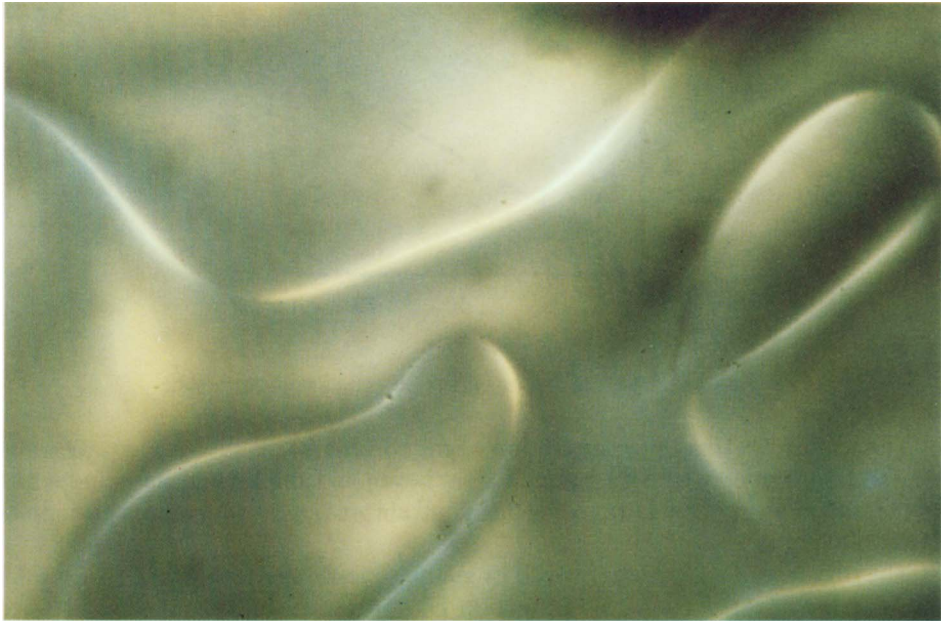
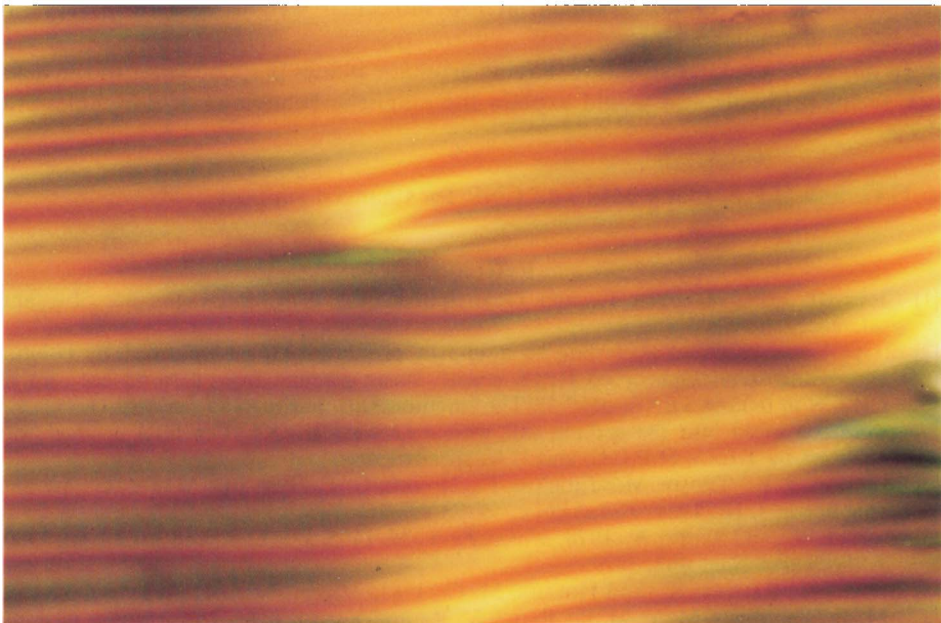


Figure 4. Herring-bone texture of the hexagonal (M) phase (crossed polars, 400 \times).



(a)



(b)

Figure 2. Cholesteric textures obtained in a 0.3 mm slide after magnetic alignment. (a) Planar texture obtained with the field perpendicular to the slide surface (crossed polars, $250\times$). (b) Fingerprint textures obtained with the field parallel to the surface; the lines of the pattern are approximately perpendicular to the field direction (crossed polars, $250\times$).

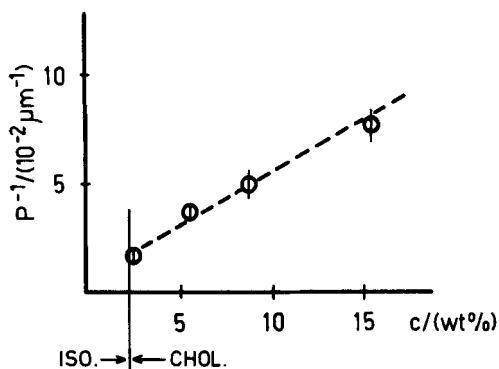


Figure 3. A plot of the inverse pitch versus concentration.

The texture obtained by evaporation of the solvent (see figure 4) shows herringbone patterns similar to those reported for the hexagonal amphiphile mesophases and for the columnar M phases formed by disodium chromoglycate [6], other chromonics [7] and DNA [8].

The structure of a few fibres formed by guanine mono-nucleosides and nucleotides has been investigated by X-ray diffraction [9]. Although differences exist between aggregates formed by different monomers, the common feature is a helical structure formed by the stacking of tetramers in which the guanine bases interact via hydrogen bonds; the outer hydrophilic part is formed by the sugar and, when present, also by the phosphate groups. The location of the hydrophobic and hydrophilic regions is reminiscent of that of DNA which, at low molecular weight, also forms type II cholesteric mesophases [10].

In our case, a similar structure, having aromatic planes perpendicular to the helix axis, seems probable and would explain the magnetic behaviour of the cholesteric phase.

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