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THE CHOLESTERIC-ISOTROPIC-BLUE PHASE TRIPLE POINT

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ABSTRACT
We have observed that the entire blue phase temperature range for cholesteric mixtures with half-pitch less than 2200Å is comparable to the range of temperatures over which the cholesteric and isotropic liquid coexists when the pitch is greater than 2200Å. The cholesteric-isotropic-blue phase triple point is described. The bâtonnets which the larger pitch cholesteric phase nucleates become unstable with respect to the smaller pitch blue phase isotropic mixture. These observations lend support to our previously proposed model that blue phases are cholesteric-isotropic emulsions which are only stable when the pitch is less than 2500Å.

Two of the many striking aspects of blue phases[1] are: 1) the extremely narrow temperature range over which they exist and 2) their occurrence only in cholesterics with half-pitch less than 2500Å. In this letter, we present observations of the cholesteric isotropic-blue phase triple point in a mixture of cholesteryl proprionate (CP) and cyanopentyl-thiobenzoate (5CTB).

Fig. 1(a) shows the phase diagram for this mixture. The blue phase width is shown in Fig. 1(b) and π times the inverse half-pitch in Fig. 1c.

When the half-pitch exceeds 2200Å, there are no more blue phases and the maximum temperature range of the blue phase coincides with the minimum of the pitch.

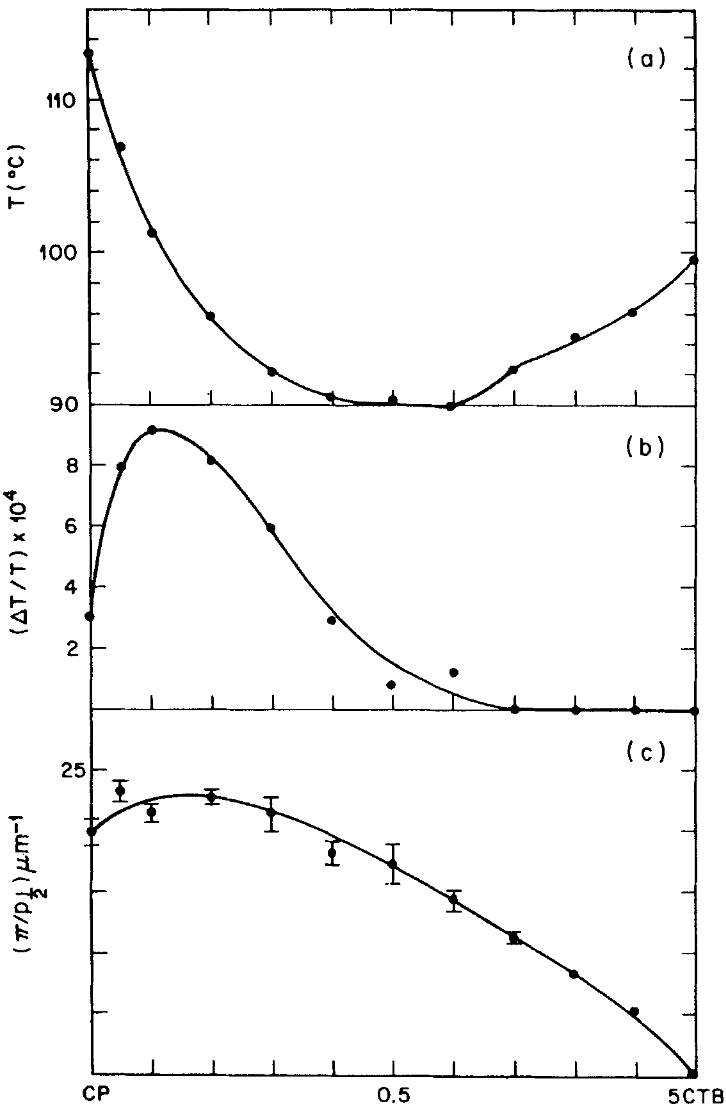

Fig. 1 Transition temperatures, blue phase temperature range and inverse of the half-pitch versus concentration.

Fig. 2(a) shows the blue phase range and the temperature range of the cholesteric-isotropic co-existence as a function of concentration. Here the blue phase range means the temperature span of blue phase I, II and III. The entire temperature range of these three blue phases is comparable in magnitude to the total range of the co-existence of the cholesteric and isotropic phases. (In some mixtures it is even smaller!) The measurements were made with increasing temperature.

The cholesteric-blue phase-isotropic co-existence is observed in the 60% mixture. The entire temperature range of the events we are about to describe, is only .01°C yet, many events take place.

Cooling the 60% mixture at .01°C every 10 minutes, white bâtonnets eventually explode into the field of view. The temperature scan is then stopped. Initially the bâtonnets grow rapidly in the direction of their long axis. As they grow, blue, fuzzy tufts (blue phase III, BP III) sprout laterally from the bâtonnets (see Fig. 3) and then condense into platelets. The bâtonnets themselves also transform into platelets and the ghost of their original shape remains (paramorphosis).

Similar events are observed for the 50% mixture of these compounds as well as certain concentrations in all the mixtures studied in reference (2) in the vicinity of their cholesteric-isotropic-blue phase triple point.

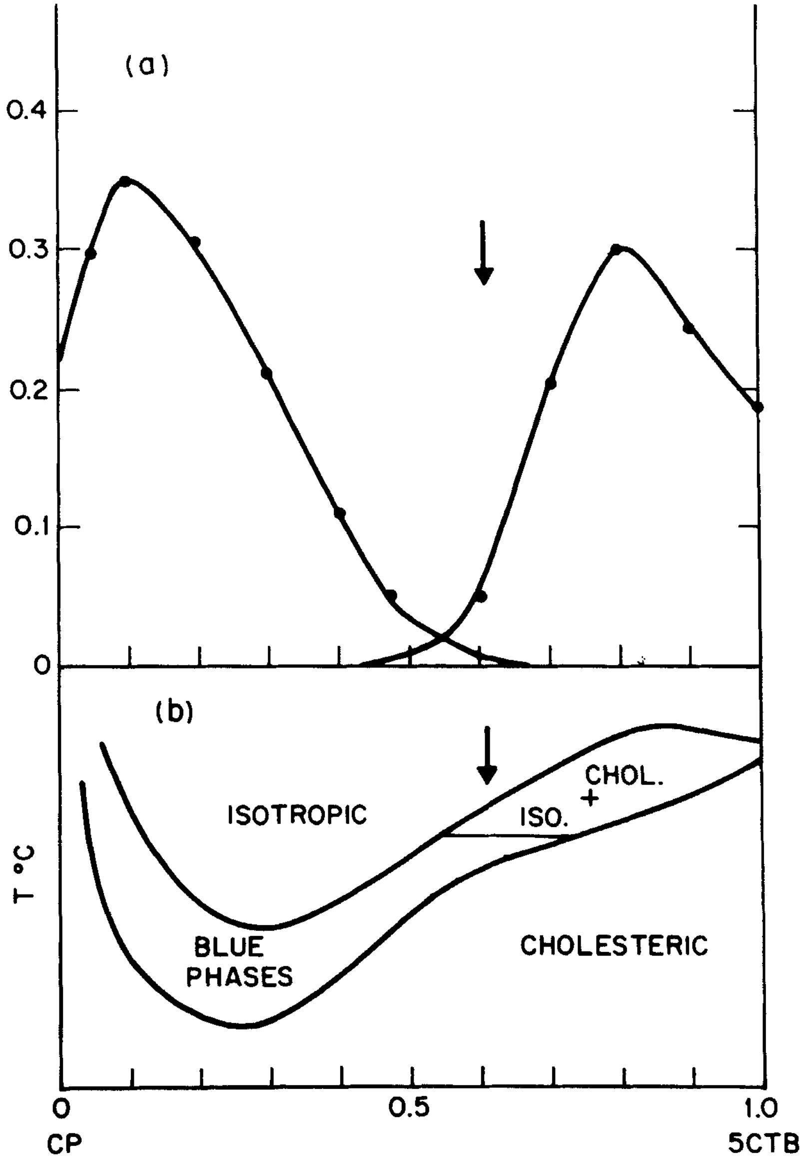

Fig. 2 (a) Temperature range of the blue phase and cholesteric plus isotropic co-existence versus concentration. The sequence narrated in the text follows along the arrow.
(b) Schematic of the phase transition and blue phase regions. A horizontal line (peritectic) separates the cholesteric plus isotropic regions from the blue phase region.

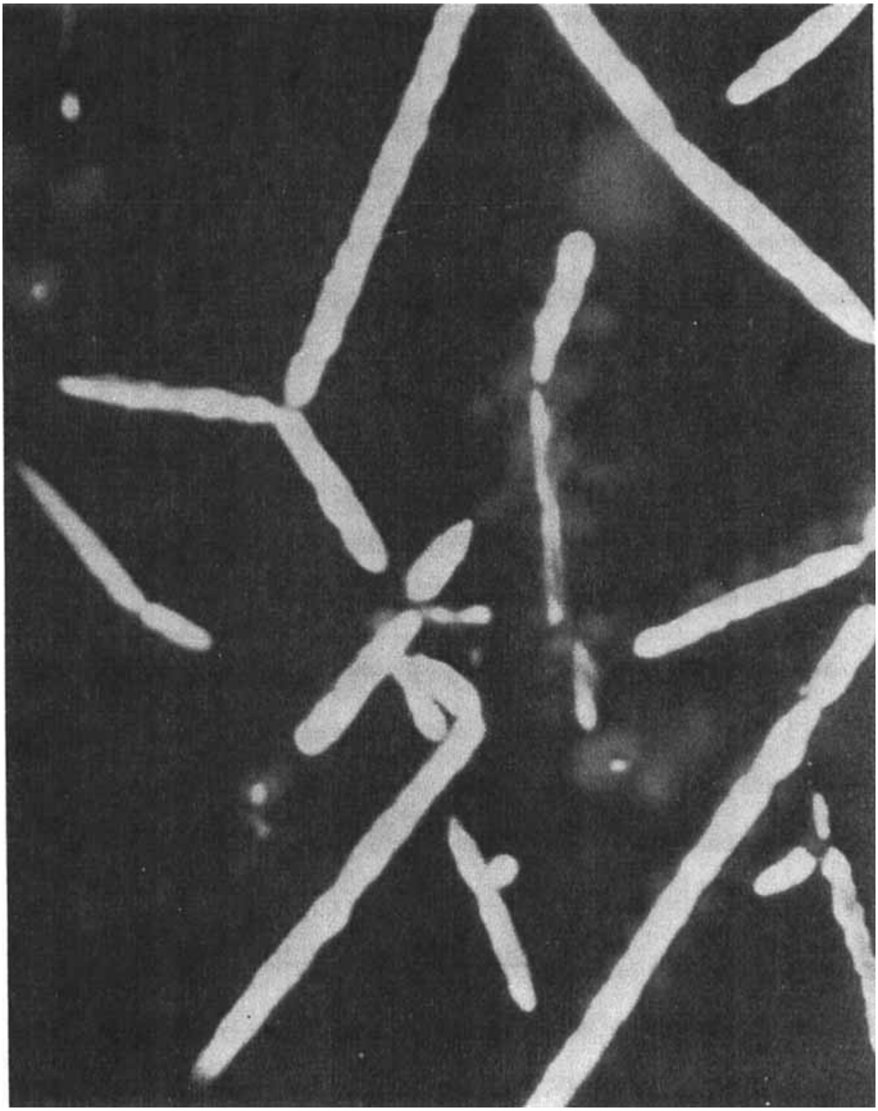

Fig. 3 Photomicrograph of coexistance of bâtonnets (cholesteric) and blue fuzz (Blue Phase III) and isotropic liquid between crossed polarizers. Note beading of bâtonnets.

Fig. 2b is a schematic of these events. Cooling along the arrow, upon entering the co-existence region, cholesteric plus isotropic, there is a phase separation into a nematic rich mixture which forms bâtonnets and a cholesteric rich mixture which remains isotropic. A blue phase condenses when the temperature drops below the peritectic and homogenizes the mixture again so that the pitch of the bâtonnets drops below the maximum pitch to form blue phases and the bâtonnets transform to blue phase.

In conclusion, blue phases and cholesteric-isotropic co-existence have comparable temperature ranges. When the pitch is greater than 2200Å, the cholesteric grows from the isotropic liquid in the form of bâtonnets. When the pitch is less than 2200Å, it does so via a blue phase.

We have recently proposed that blue phases are cholesteric-isotropic emulsions.[(2)] This model accounts for all of the features of blue phases including a critical pitch above which blue phases, or emulsions, cannot occur because of the competition between interfacial energies and loss in twist energy.

REFERENCES

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