Liquid Crystals and Liquid Crystal Polymers

by
Malcolm Mackley

Salcombe

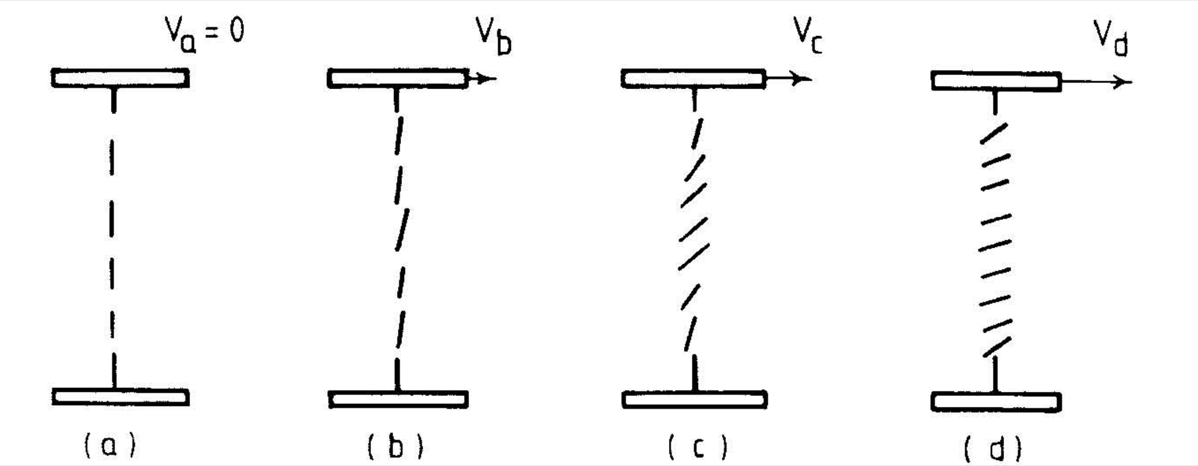
Devon

Modified, March 2015

In the beginning there were **liquid crystals (LC).** These were formed from small, semi rigid rod like molecules and were found to have liquid like properties at room temperature, but were locally ordered. This ordering resulted in the liquid crystals having optical anisotropy and useful optical properties that could for example be used in LC displays.

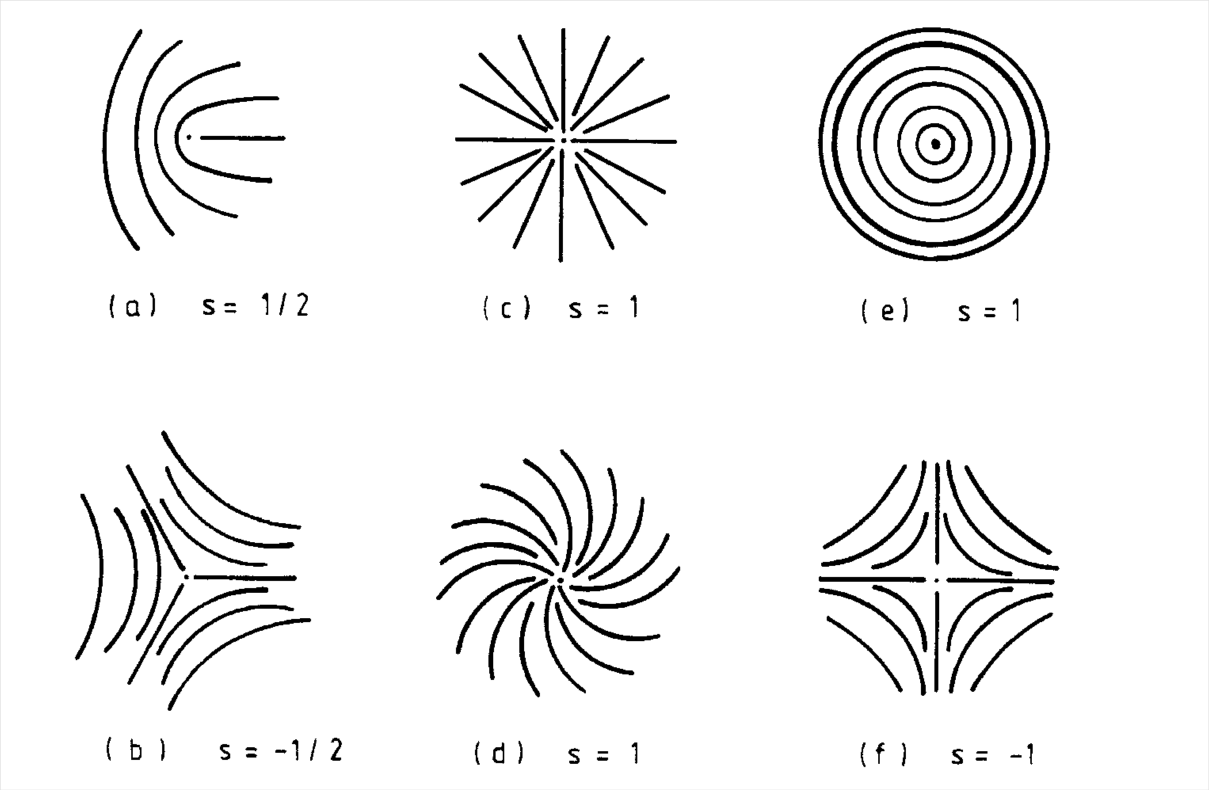
In the late 1970s **Thermotropic Liquid Crystal Polymers (LCPs)** were discovered and there was great excitement amongst the polymer science community and chemical companies that the mechanical properties of LCPs would be superior to conventional polymers. LCPs were made from semi rigid polymer chains and like there small molecule sisters, had local anisotropy and were optically birefringent.

Homeotropic initial alignment of LC “director” and the effect of shear



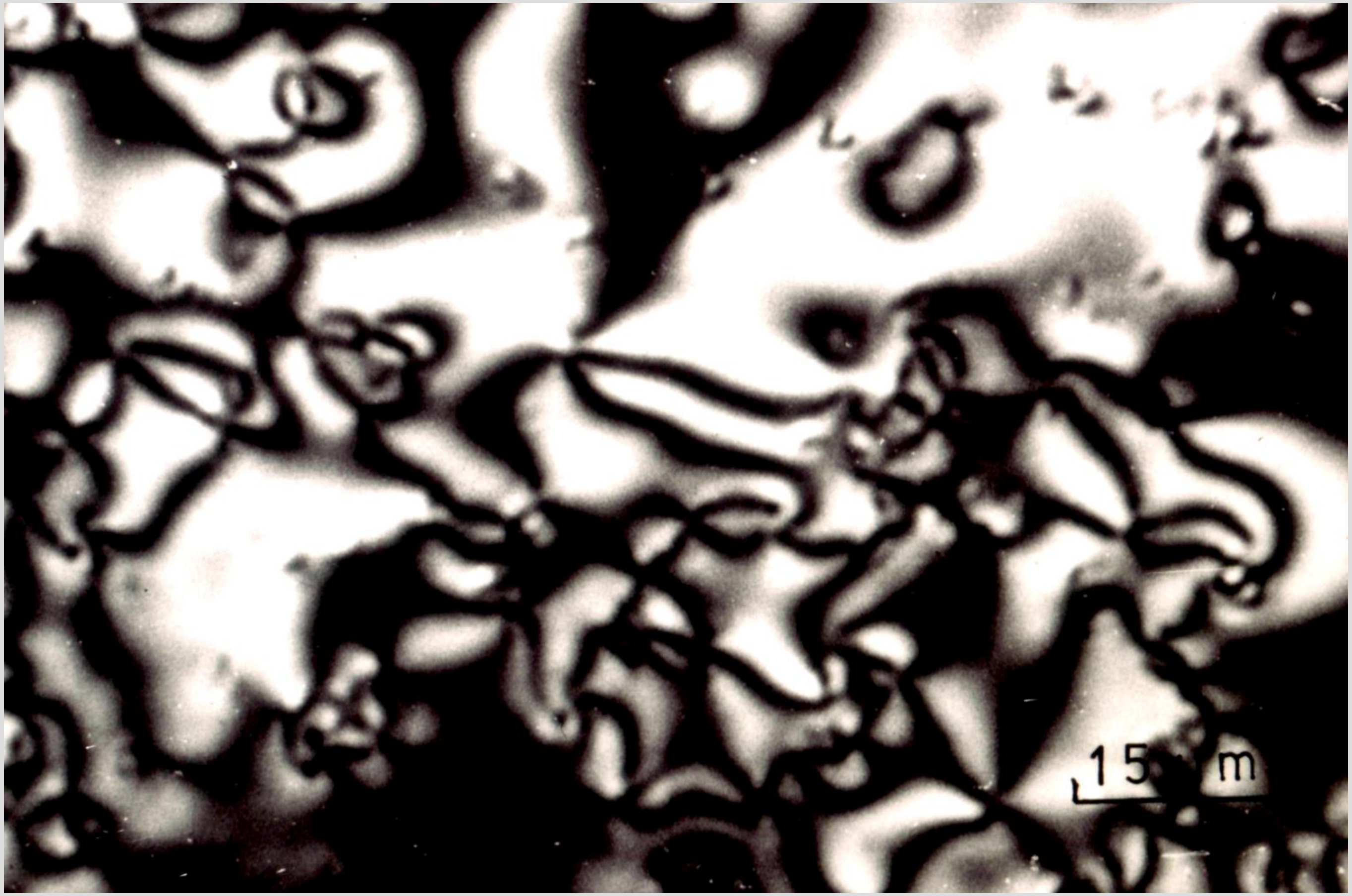
The “director” of small molecule liquid crystals (LC) is the direction of local preferred orientation for the molecules at any one position. In the above Schematic as shown in (a) with no flow, the director orientation is controlled by the director orientation at the walls of the channel. If increasing amounts shear is applied, as in the case of (b), (c) and (d), the director orients into the direction of flow although the director at the wall remains pinned by the wall “homeotropic” boundary condition.

“Disclination” singularities in Liquid crystals



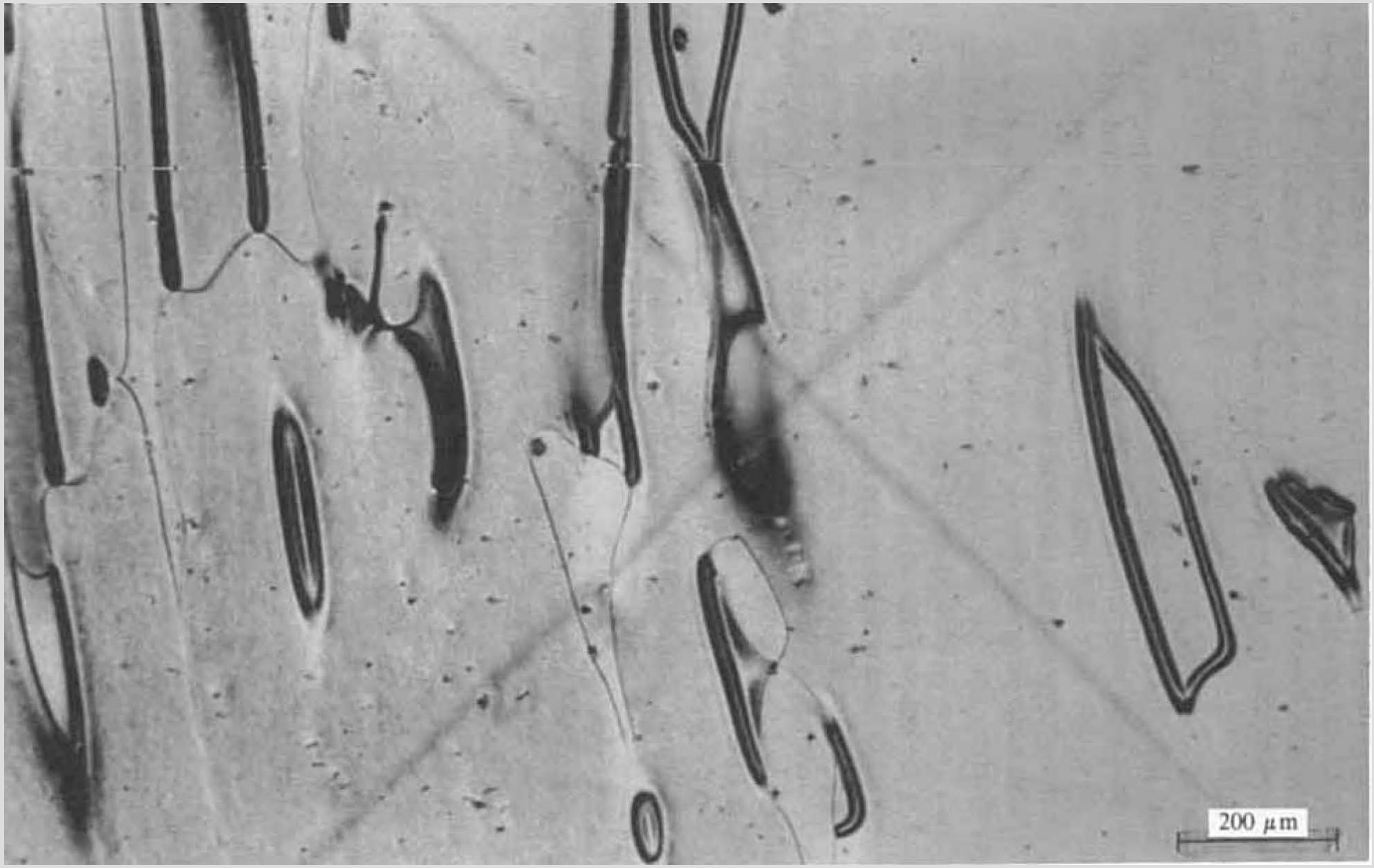
Liquid crystals invariably contain line defects known as “disclinations” and these disclinations have certain similarities to the more familiar “dislocations” that occur in metals and other crystals. F.C.Frank classified the type of disclinations that can occur in LCs and the diagram above shows the director orientation around different types of disclination singularities.

Optical cross polars micrograph of birefringent LC showing disclination singularities



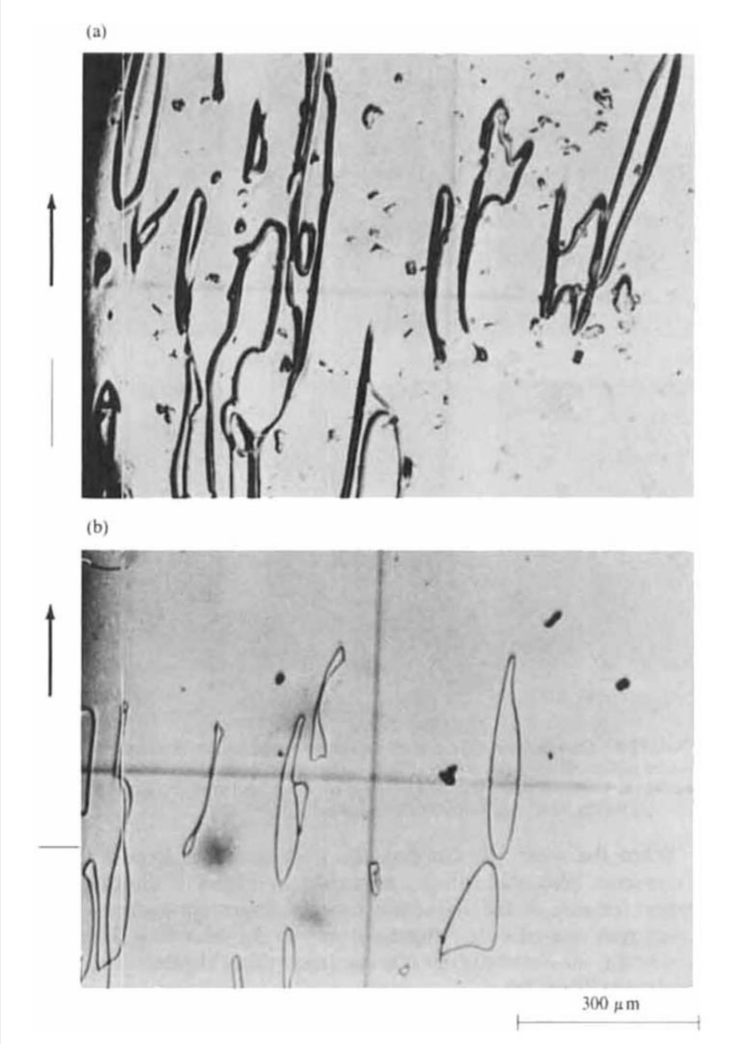
LC are birefringent and this micrograph shows typical disclination singularities that strongly influence the overall orientation of the whole sample

Optical micrograph showing LC disclination loops



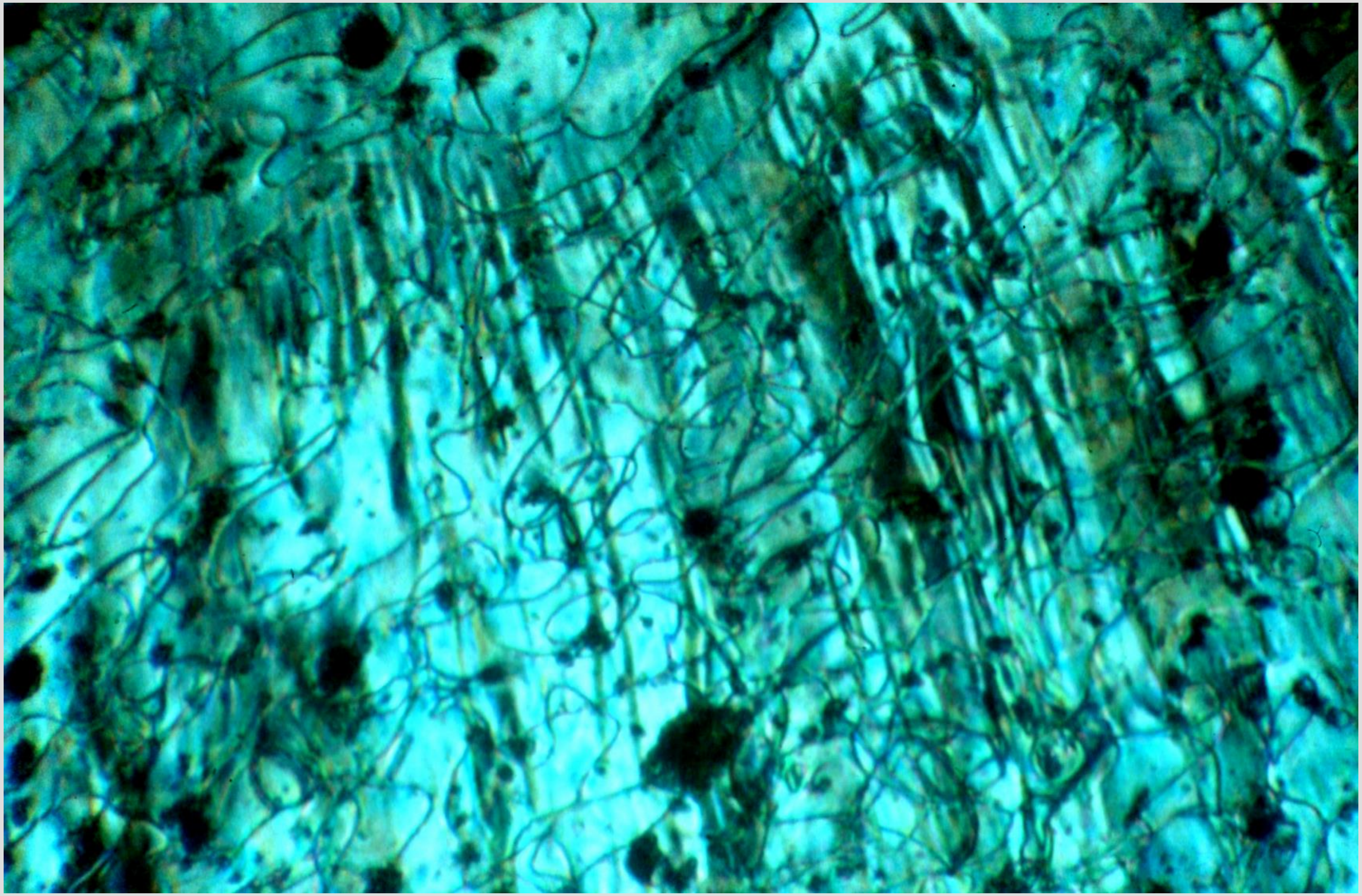
Disclination loops are common features in both LC and LCPs

Optical micrograph showing sheared disclination loops in a LC



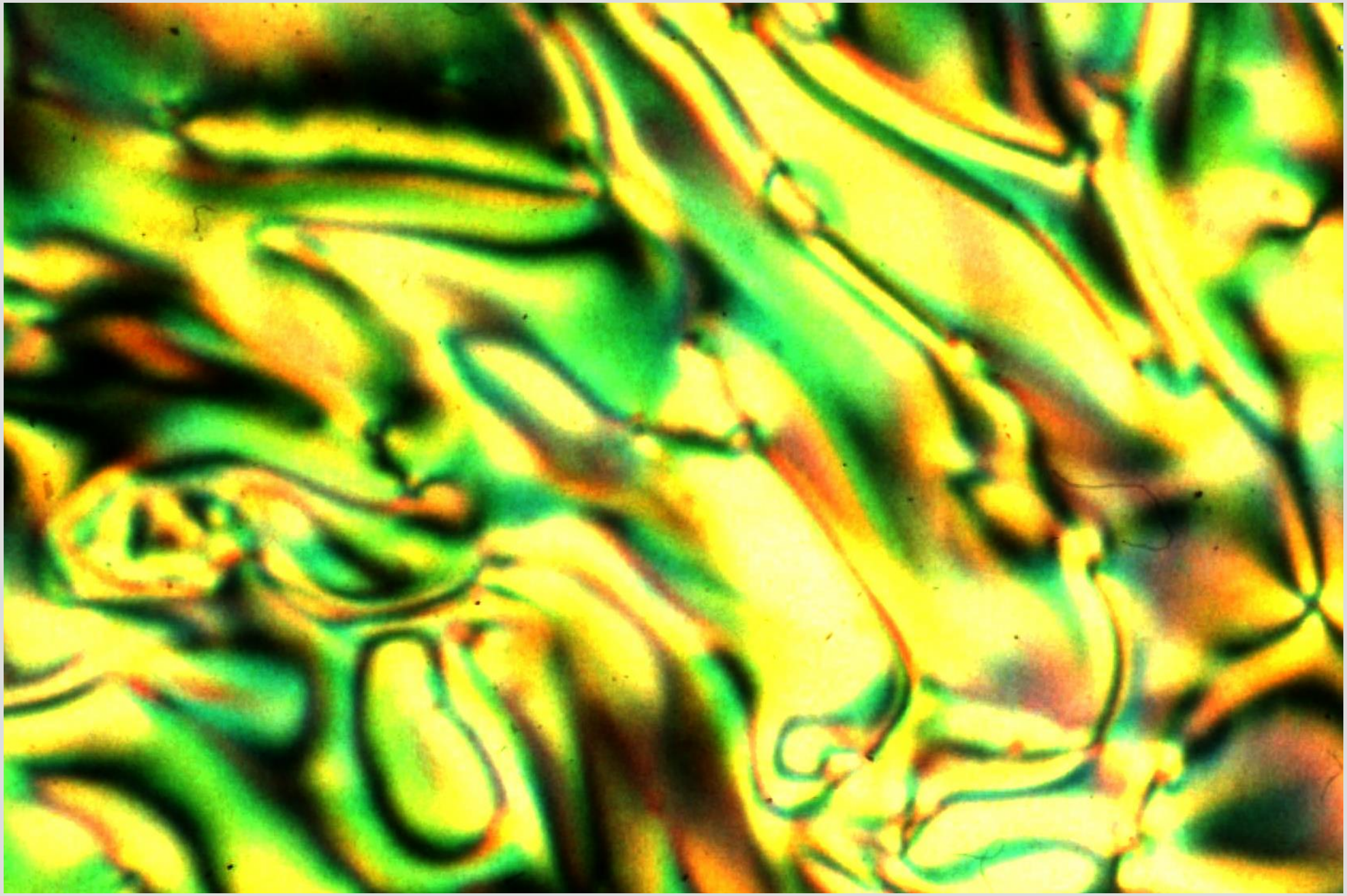
Disclination loops can be generated by shearing.

Optical micrograph showing disclination defects in a thermotropic LCP



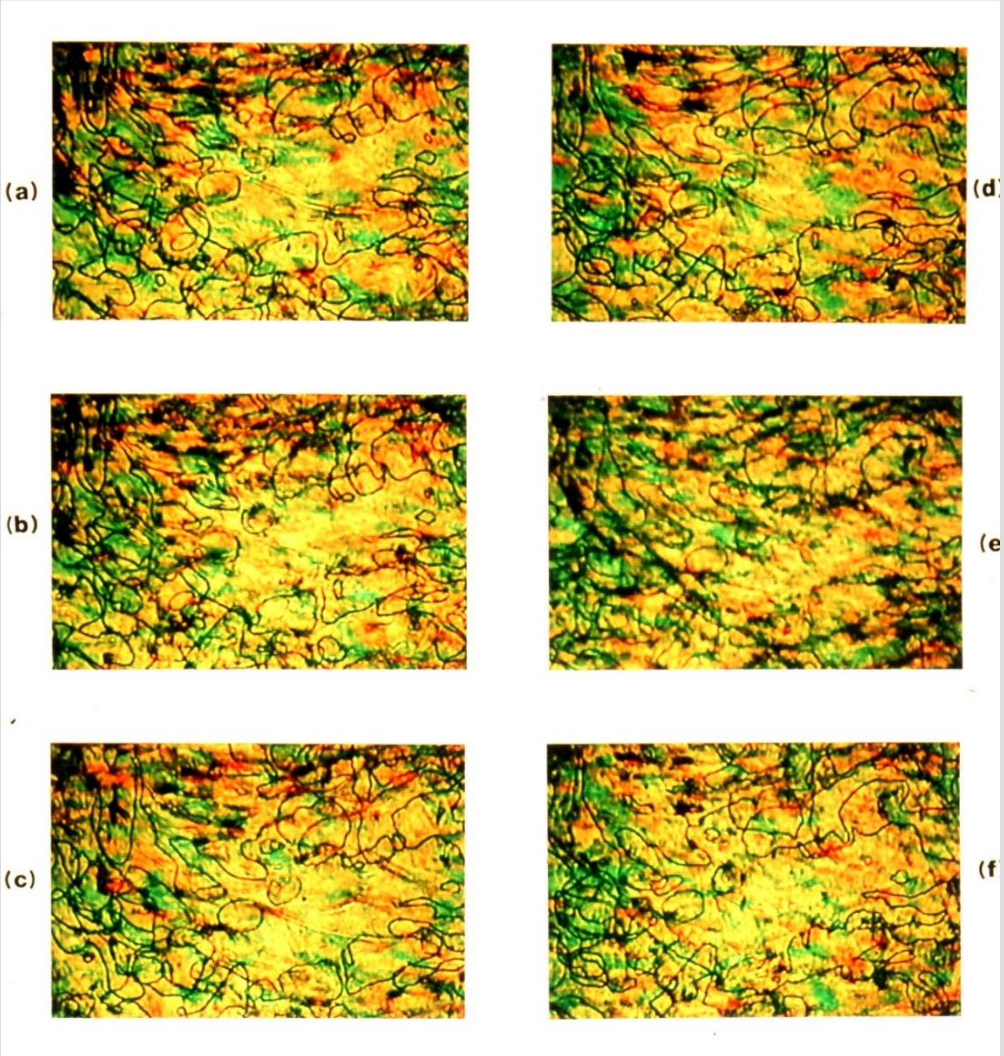
This micrograph shows a multitude of disclination loops within a thermotropic LCP melt

Optical micrograph showing disclination defects in a thermotropic LCP



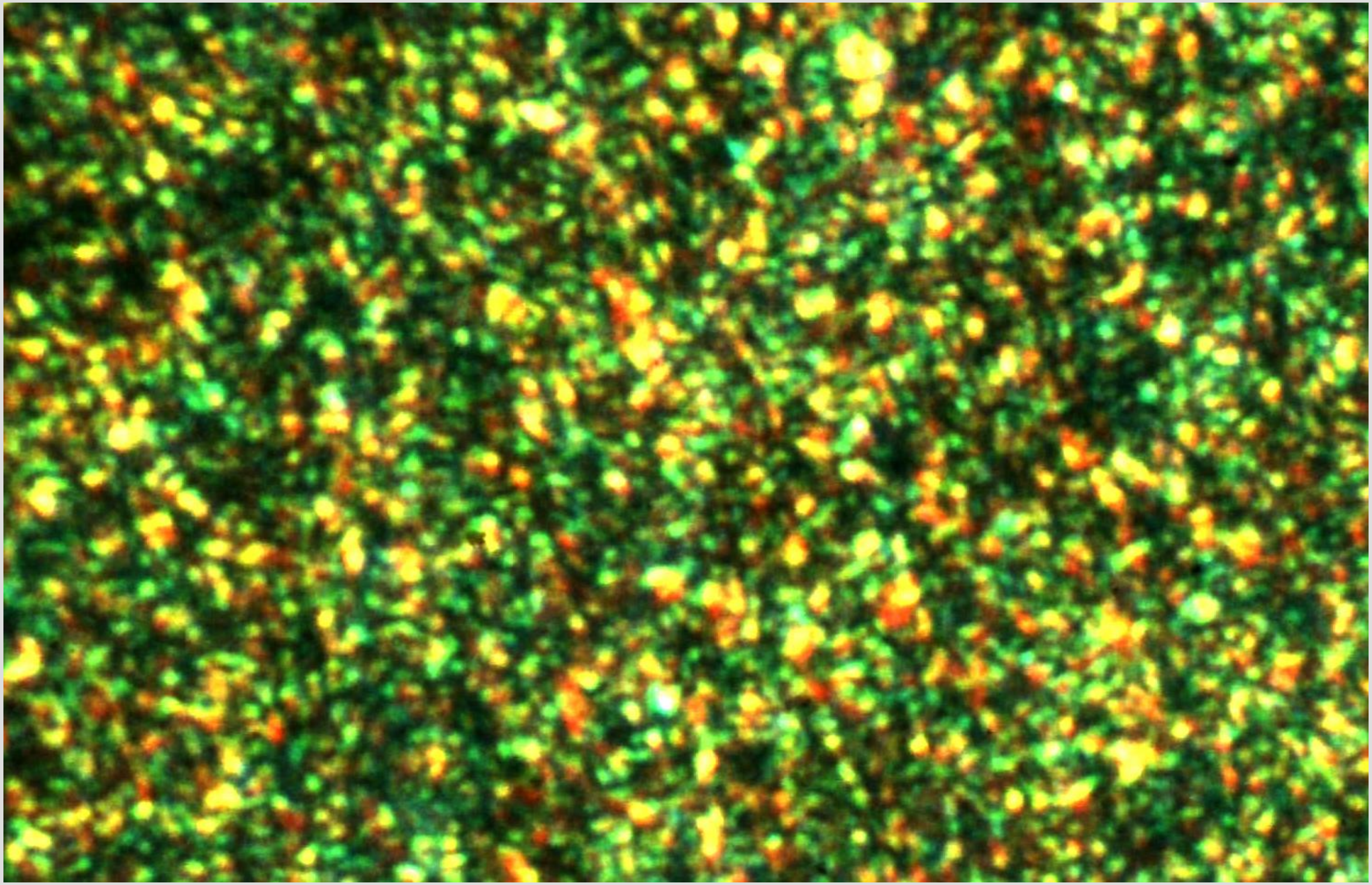
Thermotropic LCPs are high birefringent in the melt and this micrograph shows their colourful texture when viewed between crossed polars

Optical micrographs of Thermotropic LCP viewed between cross polars at different angles of rotation



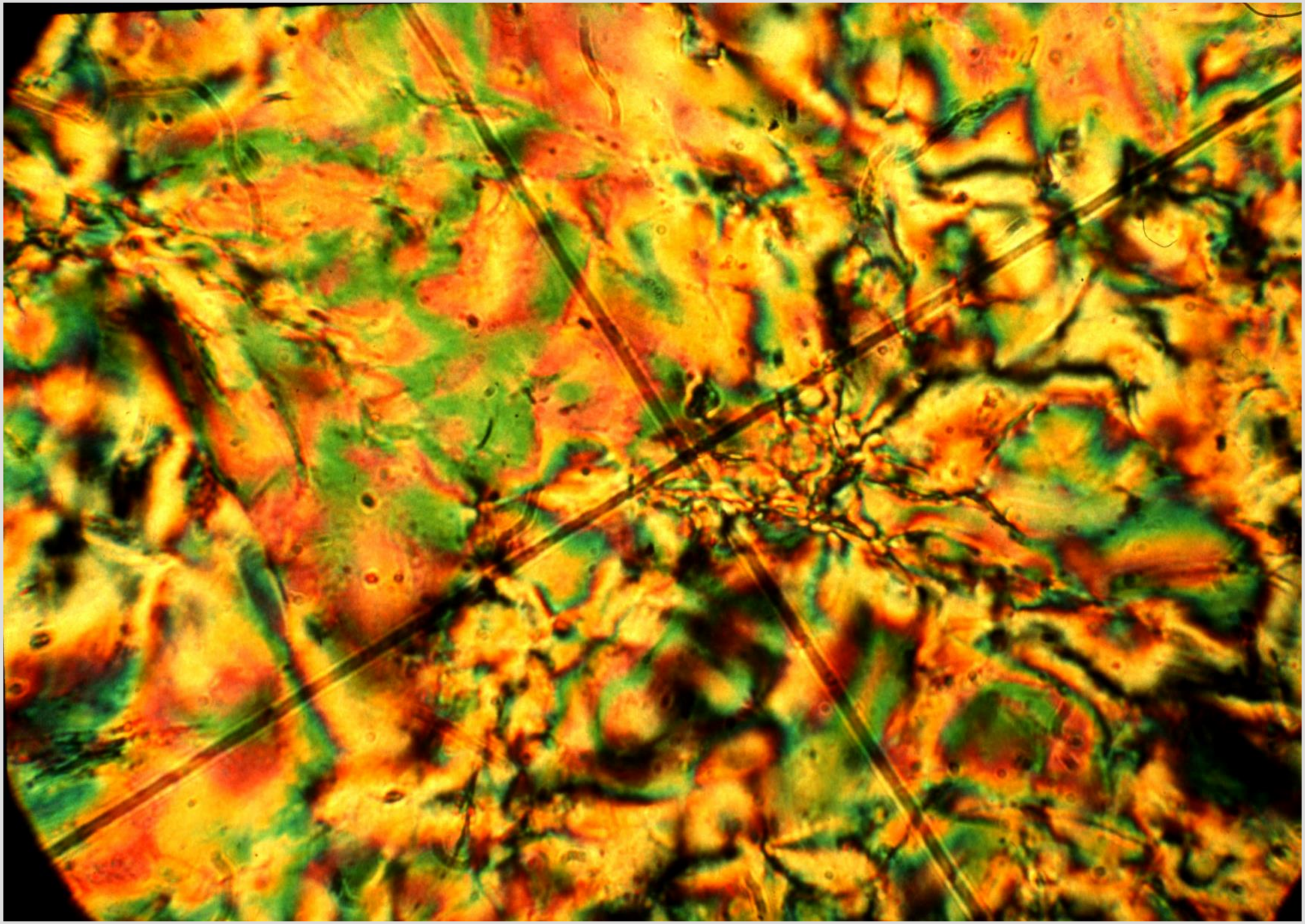
These micrographs show dense defect textures in LCPs and indicate that local orientational ordering of the LCP is controlled by the defect textue

Optical micrograph showing dense disclination defects in a thermotropic LCP



High local ordering within a dense defect texture

Optical micrograph of disclination defects in a thermotropic LCP



Thermotropic LCPs make colourful pictures

LCP Summary

Thermotropic LCPs exhibit local ordering, however it is very difficult to control the disclination defect texture and ordering within material.

Thermotropic LCPs have found niche applications where the anisotropic properties can be exploited. See for example; http://www.celanese.com/ticona/products/Vectra-LCPZenite-LCP.aspx