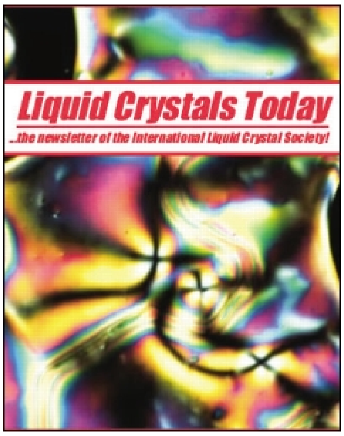


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# Glass Dispersed Liquid Crystals

David Levy[a]
[a] Instituto de Ciencia de Materiales, CSIC, Madrid, Spain

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# Glass Dispersed Liquid Crystals

**David Levy, Instituto de Ciencia de Materiales, CSIC, Serrano 115 dpdo, 28006 Madrid, Spain**

## In this issue:

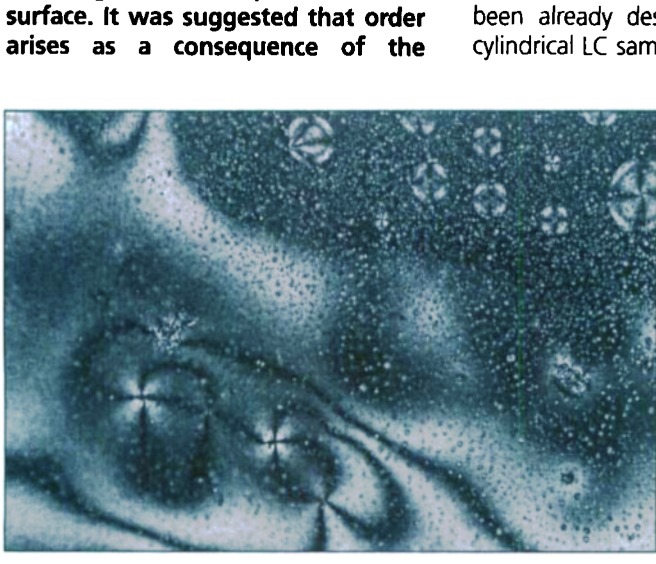


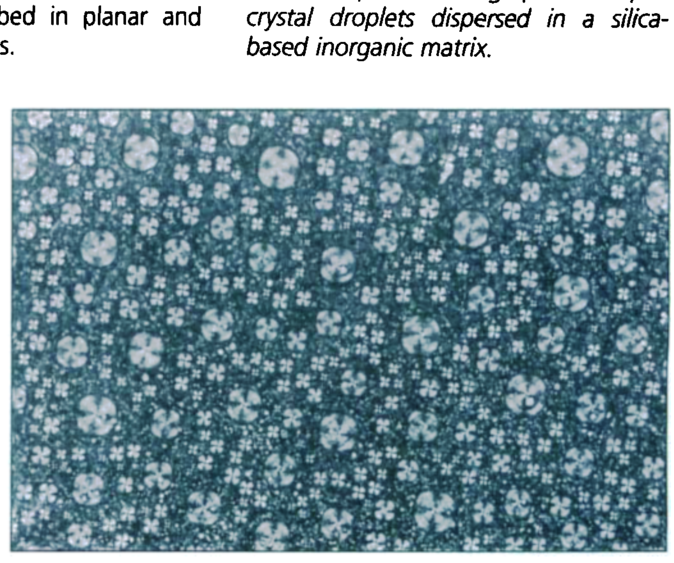
**Liquid crystals can be trapped into *inorganic* (silica) substrates by sol-gel processes. The sol-gel process consists of hydrolysis and polycondensation reactions of metal organic monomers, i.e. organoalkoxy silanes, which allows the formation of a silica gel-glass. These processes have been used since 1984 for trapping organic molecules into inorganic oxides; usually, single molecules are trapped into isolated gel-glass (nm size) pores. However, it is possible, by chemical means, to induce larger (0.1–10 $\mu$m) cavities in the network of the gel-glass allowing the formation of embedded micron size droplets of low molecular weight nematic LC molecules. Surface variations in these cavities (e.g., providing a molecular oriented surface using Si–$CH_2CH_3$ groups on the pore cage) may allow a lamellar structure and alignment of the nematogenic LC compounds at the surface. It was suggested that order arises as a consequence of the chemical affinity between the apolar character of the pore surface and the lipophilic groups of the LC. Therefore, the main concern has been to ascertain whether the sample manufacturing keeps the LC structure, thus giving gel-glass dispersed liquid crystals (GDLCs) with electro-optical response.**

LC microdroplets scatter visible light, and the sample is white opaque or milky. When a film of GDLC, 20–30 micron thickness, is sandwiched between glass plates with transparent conductive electrodes, it can be made to switch from opaque to a clear transparent condition, upon application of a voltage to the electrodes, forming a light shutter. Upon removal of the voltage, the droplets return to their original scattering orientation. Reorientation of the GDLCs has been achieved with electrical and optical fields. An $Ar^+$ laser focused onto the sample produces several diffraction patterns which have been already described in planar and cylindrical LC samples.

Several monomers and mixtures under different reaction conditions and using different LCs have been used in order to vary the pore size and surface properties of the silica cages, and resulted in large variations in GDLC characteristics, i.e. droplet sizes, threshold voltages, switching times, and contrast ratio. GDLCs have the advantage of an improved substrate for both optical and mechanical properties, as well as high enhanced photochemical and thermal stability. The trapping technique provides a convenient method for the protection of LCs from physical damage and extends the range of applications through increased flexibility in handling of the material.

*(Below) Optical micrographs of liquid crystal droplets dispersed in a silica-based inorganic matrix.*





GDLC applications are as diverse as the grades of complexity of their function. For example, decorative and utilitarian devices, such as those used in the production of internal or external 'smart-windows' (switching between opaque and transparent states) may be used with no loss of light. Flat displays for applications (optical switches and modulators), such as vision panels and presentations to show numerical data or images, are based on an ON/OFF GDLC optical switching with the absence of an angle-of-view dependence. GDLC displays have a complete 180° angle of view, and do not need polarizers as well as having a switching time of less than one millisecond.

The feasibility of applying these materials to coloured displays has been explored. Colour emissive projection displays containing fluorescent RGB masks on the back plane, behind the GDLC cell, have been recently proposed. A UV lamp over the front plane excites the chromophors located under switched pixels, whereas unswitched pixels scatter the incoming UV light and the residual fluorescence. This setup may then be used for projection, the display behaving as an emissive display (i.e. like a commercial TV), and takes advantage of the photostability of sol-gel glasses as compared to similar systems. Two distinct sol-gel processes are used for trapping the LC and for preparing the fluorescent matrix of the GDLC projection display. In all cases, the absence of polarizers is a clear advantage of these displays, as it increases the transmission of the transparent state up to the Fresnel limit.

GDLCs suffer from several problems that are still under investigation. For example, light scattering losses due to interface problems. ON transmission problems are mainly due to the unmatched refractive indices between the LC and the vitreous matrix. High contrast ratios were achieved (30:1), but further work is required in order to improve the OFF and ON transmissions.

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