Visualization of Continuous Surface Shear Stress Vector Distributions

Lecture One

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The liquid-crystal phase of matter is a weakly ordered, viscous, fluid-like state that exists between the nonuniform liquid phase and the ordered solid phase of certain organic compounds. Liquid crystals can exhibit optical properties that are characteristic of solid, crystalline materials.

Shear-sensitive cholesteric (chiral nematic) liquid crystal coatings are comprised of helical aggregates of long, planar molecules arranged in layers parallel to the coated surface. Each layer of molecules is rotated, relative to the layer above and below it, about an axis perpendicular to the coated surface. The longitudinal dimension along the helical axis (the pitch) is on the order of the wavelengths of visible light. This layered, helical structure causes such materials to be extremely optically active. White light incident normal to the coating surface is selectively scattered at a wavelength proportional to the pitch of the helix. Under applied shear at either boundary of the coating, the local pitch of the helical structure is altered and the local helical axis is tilted relative to the no-shear state. The net result is that the incident light is reflected in a highly directional manner, as a three-dimensional color spectrum in space.

Schematic of shear-sensitive liquid-crystal coating (SSLCC) molecular structure (after Fergason, 1964).