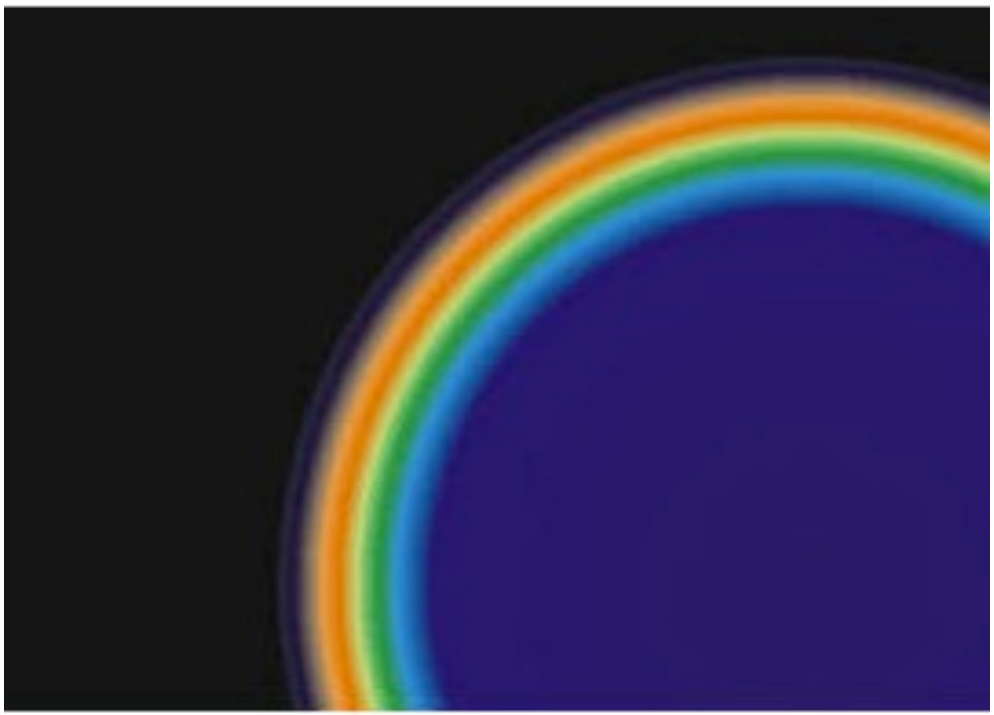
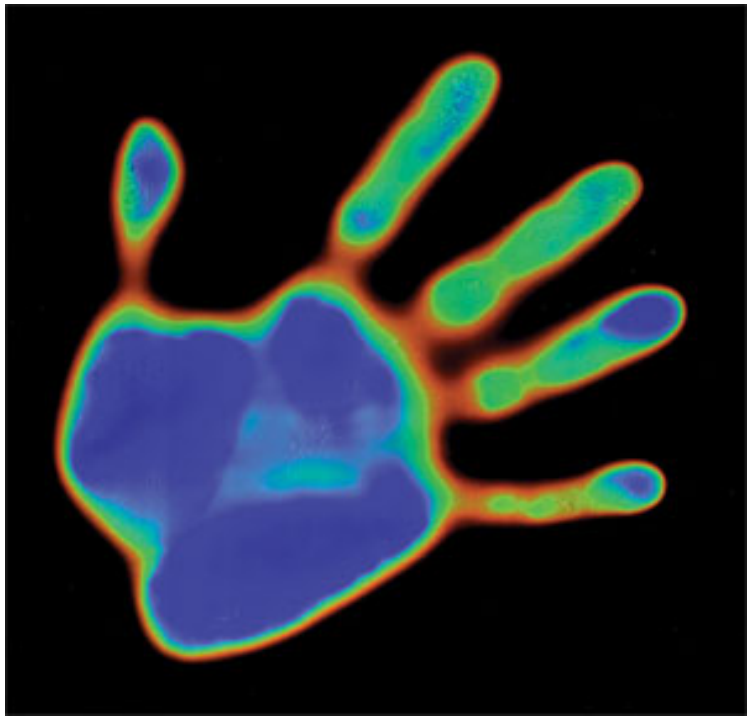
Liquid Crystal Thermography LCT





Liquid Crystals : Phase change of chiral nematics

Some organic molecules can exist in a state between solid and liquid : **Liquid crystals**

Decreasing temperature ← Reversible process → Increasing temperature

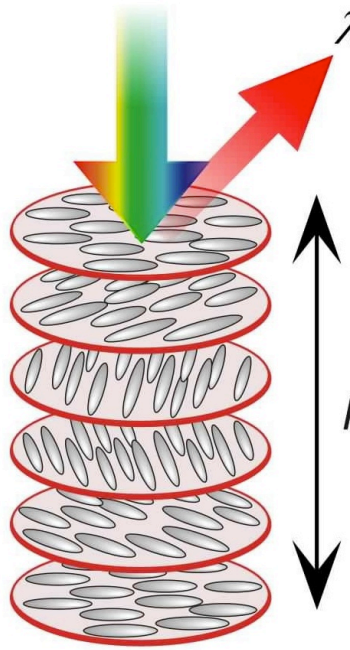
Crystalline solid phase

Chiral nematic liquid crystal mesophase

Isotropic liquid phase

Mechanical properties of a fluid
Optical properties of a crystalline solid

Liquid Crystals : Thermochromic Response



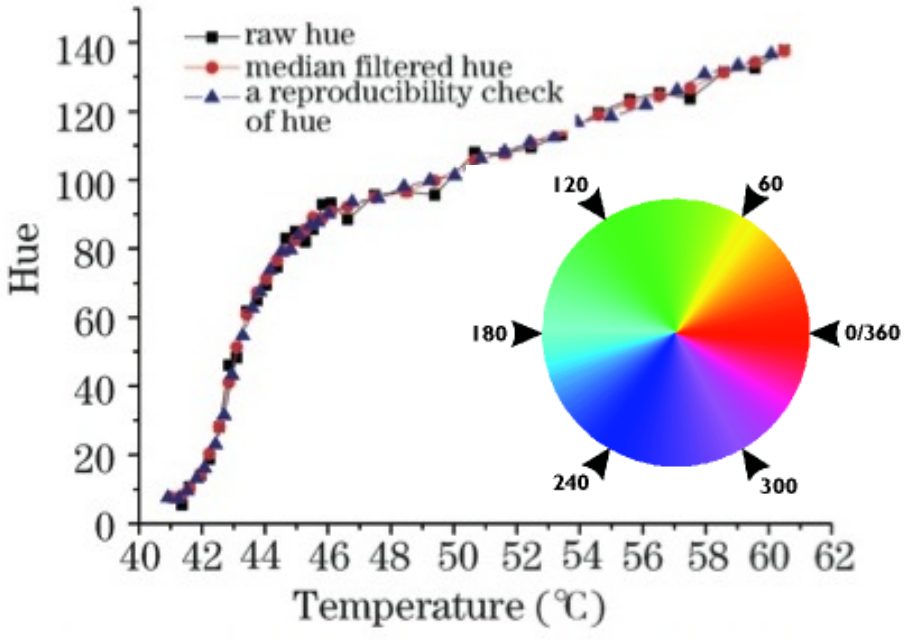
Chiral mesophase

$\lambda_{ref.}$: wavelength of the selectively reflected light

$$\lambda_{ref}(T) = p(T)\eta\sin\vartheta$$

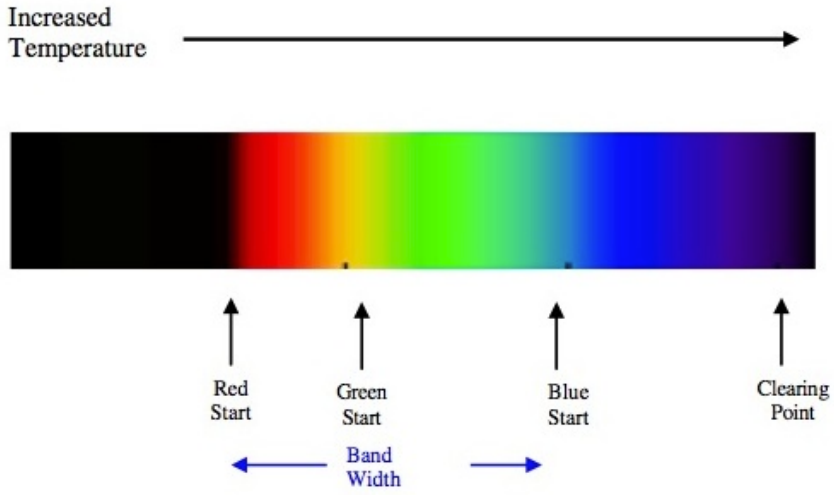
$p/2$ = pitch / 2

Hue-Temperature Calibration

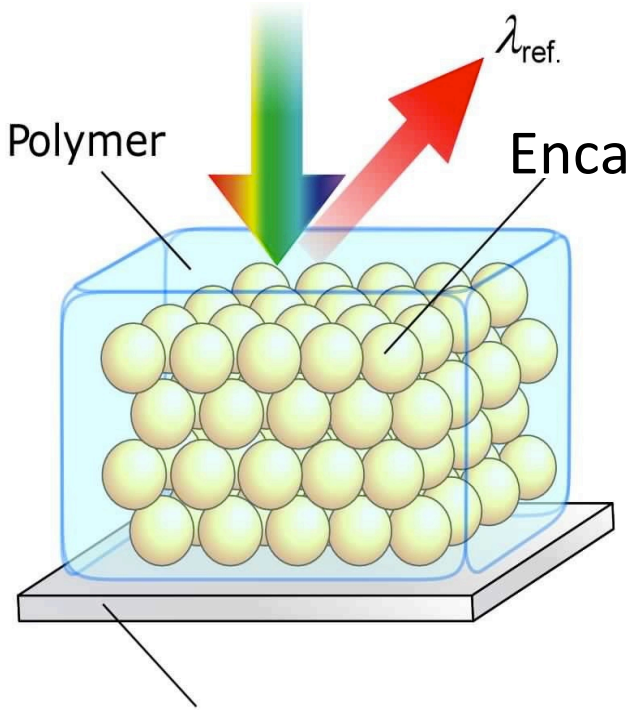


Periodic layered structure of the chiral nematic mesophase acts as a 3D diffraction grating to cause a Bragg type scattering of the incident light.

Since, pitch $p = p(T)$ and usually increases with increasing temperature, the wavelength of the reflected light decreases with increasing temperature: **red** to **blue** colour transition



Liquid Crystal Thermography : Thin film application

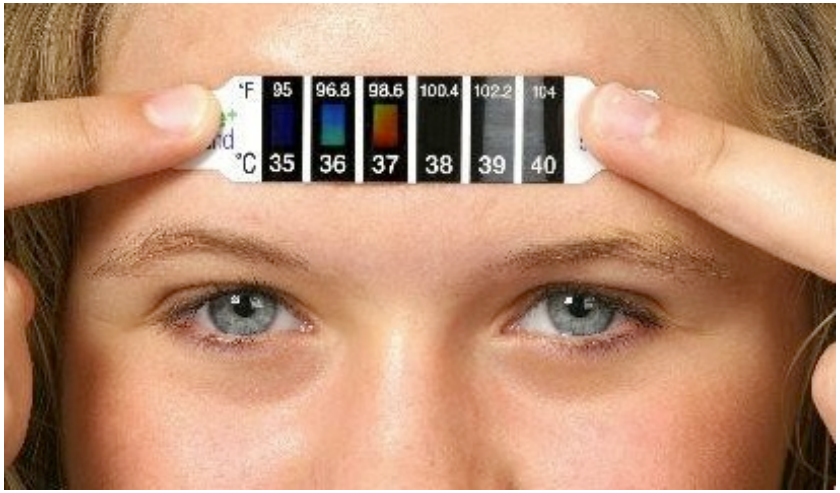


Liquid crystals change their reflected colour as a function of temperature when illuminated by white light

Liquid crystals used either as:

- Suspensions of micro-encapsulated 5-10 micron spheres, each containing liquid crystals, illuminated with a thin light sheet to provide local temperatures in fluid flows
- Applied as a thin film on non-reflective black painted surfaces to provide qualitative and quantitative surface temperature fields
- Set into thin polymer sheets with black substrates, usually adhesive, for measuring surface temperature profiles

Liquid Crystal Thermography : Applications



Liquid Crystal Thermography : Characteristics

Advantages

- Provides a quick visual qualitative observation of the surface temperature profile
- Can be calibrated with a digital colour camera and isothermal surface control to provide accurate quantitative temperature fields to +/- 0.1C
- Typically operate between -30C to 120C with bandwidths of 0.1C to 30C
- A High spatial resolution of around 1 micron, depends on camera optics
- Provides both transient and steady state surface temperature profiles
- A Fast time response of around 100ms
- Thermometry uses visible light and is independent of surface emissivity
- Relatively cheap technique: camera, recorder, lighting etc…

Disdavantages

- Requires a stable uniform white light source with no infrared IR or ultraviolet UV components. IR will cause radiant heating of surface, and UV will degrade the liquid crystal compounds.
- Must be calibrated in-situ using the same optics as the final experiment
- Test subject must be prepared before measurements and the liquid crystals can be difficult to apply to complex surface geometries
- Can be intrusive due to changes in the heat conduction properties of the body
- Can not be used for large subjects such as houses etc…