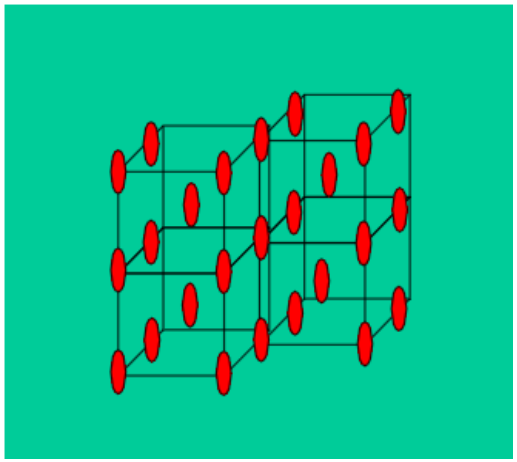
Liquid Crystal Polymer

Soumyajit Nayak

Department of Metallurgical & Materials Engineering
National Institute Of Technology, Rourkela

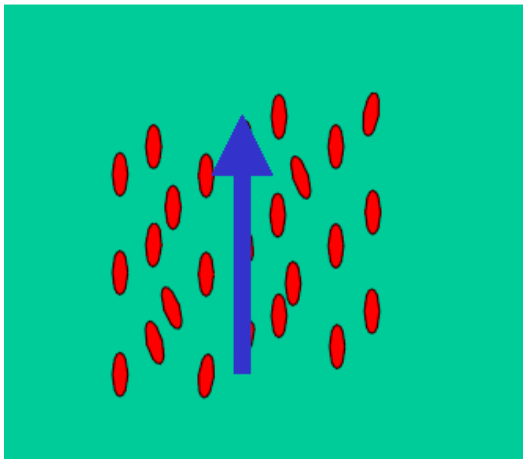
Liquid Crystals : Introduction

Crystalline



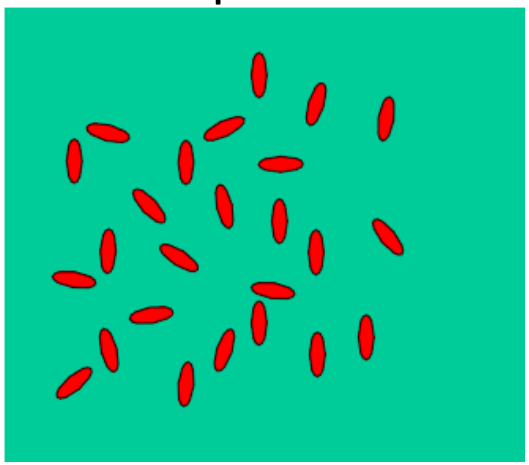
3D orientation
Rigid Structure

Liquid Crystals



Ordered position
Glassy flow

Liquids



No Order
Fluid Flow

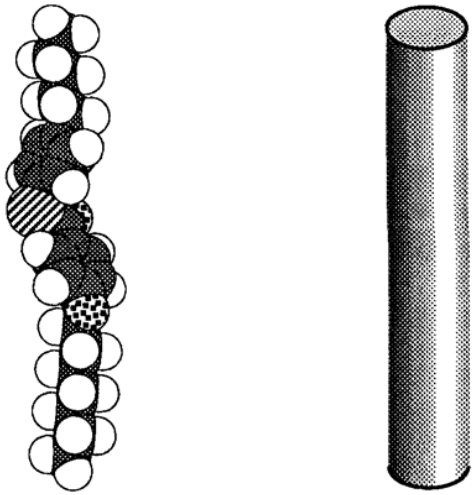
LC molecules tend to maintain their orientation, like the molecules in a solid, but also move around to different positions, like the molecules in a liquid.

Liquid Crystals : Introduction

- A state that occurs between a solid & a liquid
- Possess properties characteristics of both liquids & crystalline solids
- Also possess properties not found in either liquids or solids
- changes colour with temperature

Liquid Crystal Polymer

- These are materials containing molecules with rigid, bulky groups which behave more or less like molecular ‘rods’ called **mesogens**. These rods can form crystals with long range orientational or positional order.

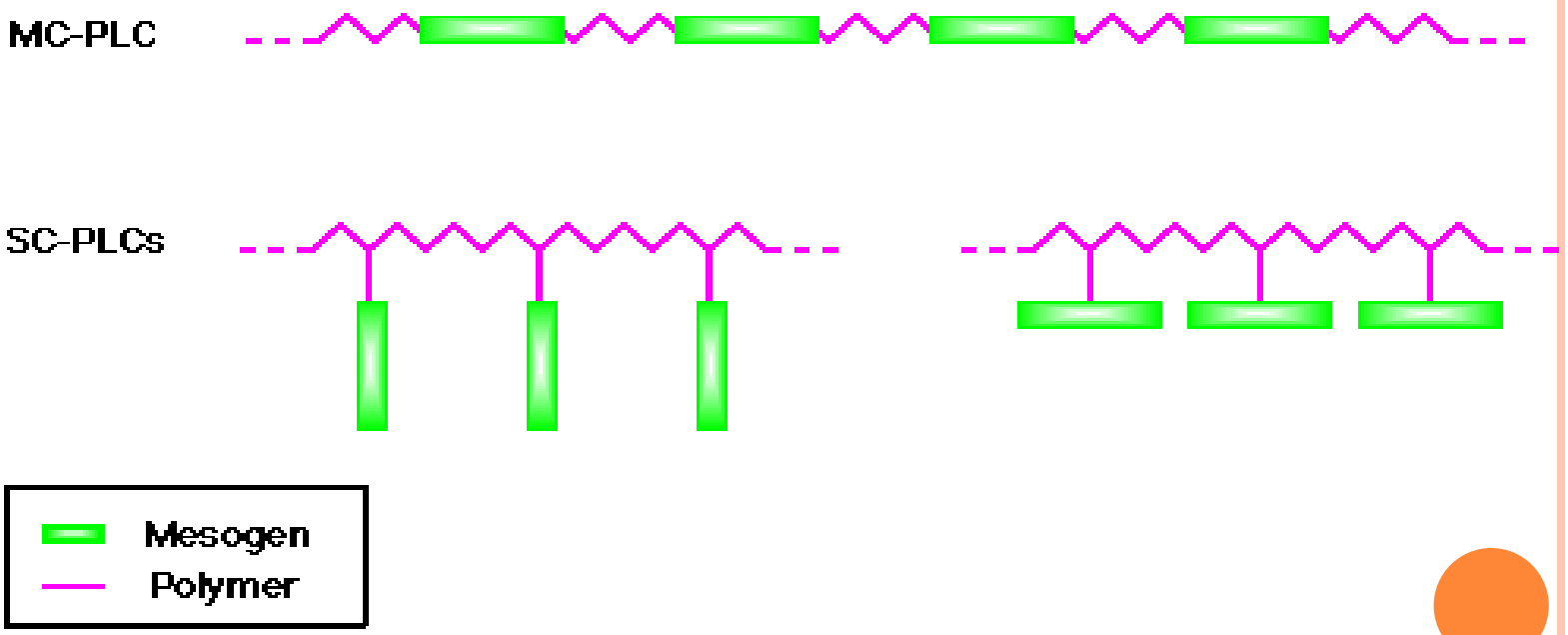


- Polymers containing rigid units also display liquid crystalline order, and are referred to as liquid crystalline polymers (LCPs)

- These are a class of aromatic polymers.

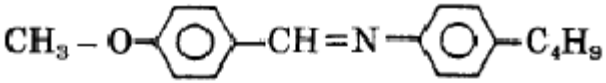
LCP Types:

- The placement of the mesogens plays a large role in determining the type of PLC that is formed
  - main-chain polymer liquid crystals
  - side-chain polymer liquid crystals

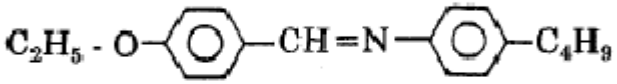


Typical Liquid Crystalline Molecules

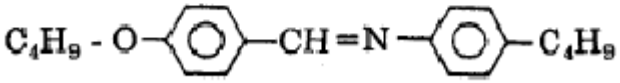
- cholesterol ester
- phenyl benzoates
- paraffins
- glycolipids
- methoxybenzilidene butylanaline (“MBBA”)



MBBA



EBBA



BBBA

Types of liquid crystals

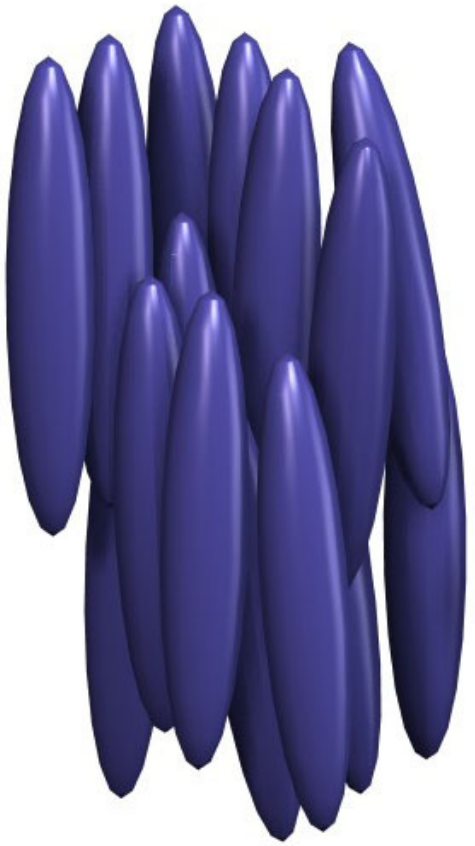
- Thermotropic - Phase transition depends on temperature
  - Nematic
  - Smectic
  - Cholesteric

- Lyotropic - Phase transition depends on temperature & concentration

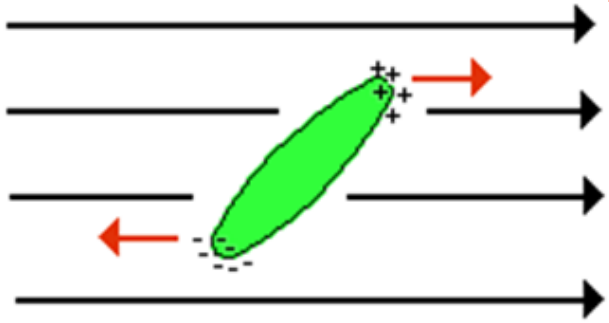
- Metallotropic - Phase transition depends on temperature, concentration and the inorganic-organic composition ratio

Nematic phase

- most common LC phase
- rod-shaped organic molecules have no positional order
- have long-range orientational order
- macroscopic anisotropy in many material properties
- Nematics have fluidity similar to that of ordinary (isotropic) liquids



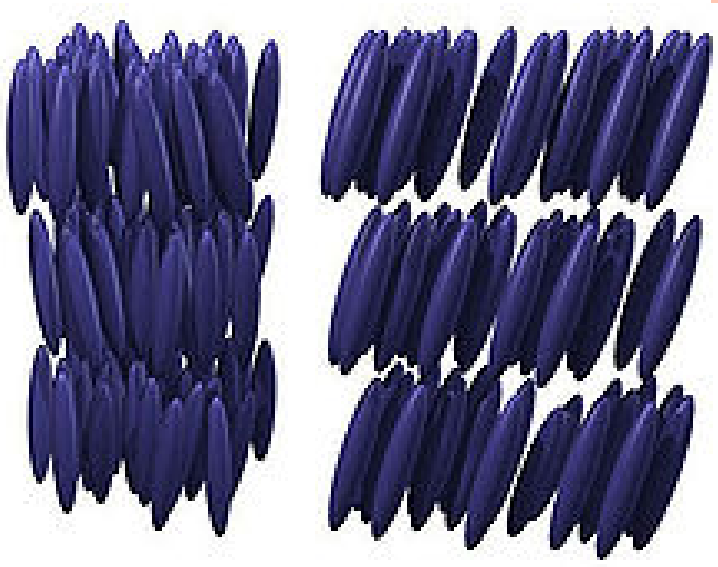
Nematic phase



- orientation may be manipulated with an electric field as well with a magnetic field, and the polarization of light will follow the molecular orientation as it changes through a cell
- these external perturbation are called *‘directors’.*

Smectic phase

- form well-defined layers that can slide over one another
- more order and higher viscosity
- smectic phase occurs at lower temperature
- many different smectic phases, characterized by different types and degrees of positional and orientational order



Smectic phase

Smectic A phase

- molecules align perpendicular to the layer planes

Smectic C phase

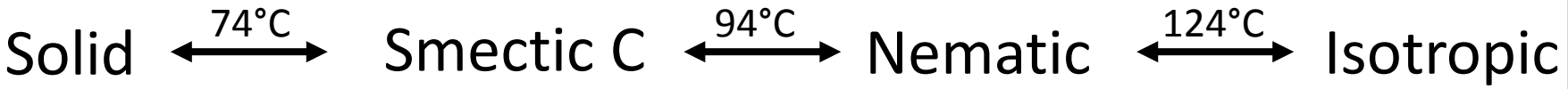
- alignment of the molecules is at some arbitrary angle to the normal

As temperature increases….

- The first liquid crystal phase is the *smectic* A, where there is layer-like arrangement as well as translational and rotational motion of the molecules.
- A further increase in temperature leads to the *nematic* phase, where the molecules rapidly diffuse out of the initial lattice structure and from the layer-like arrangement as well.
- At the highest temperatures, the material becomes an *isotropic* liquid where the motion of the molecules changes yet again.

Example of phase changes…

4, 4’-di-heptyloxyazoxybenzene



Advantages of LCP

- High Heat Resistance
- Good Chemical Resistance
- Low Warpage
- Flame Retardant
- Low Viscosity
- Good Moldablity
- High Flowability
- Good Dimensional Stability

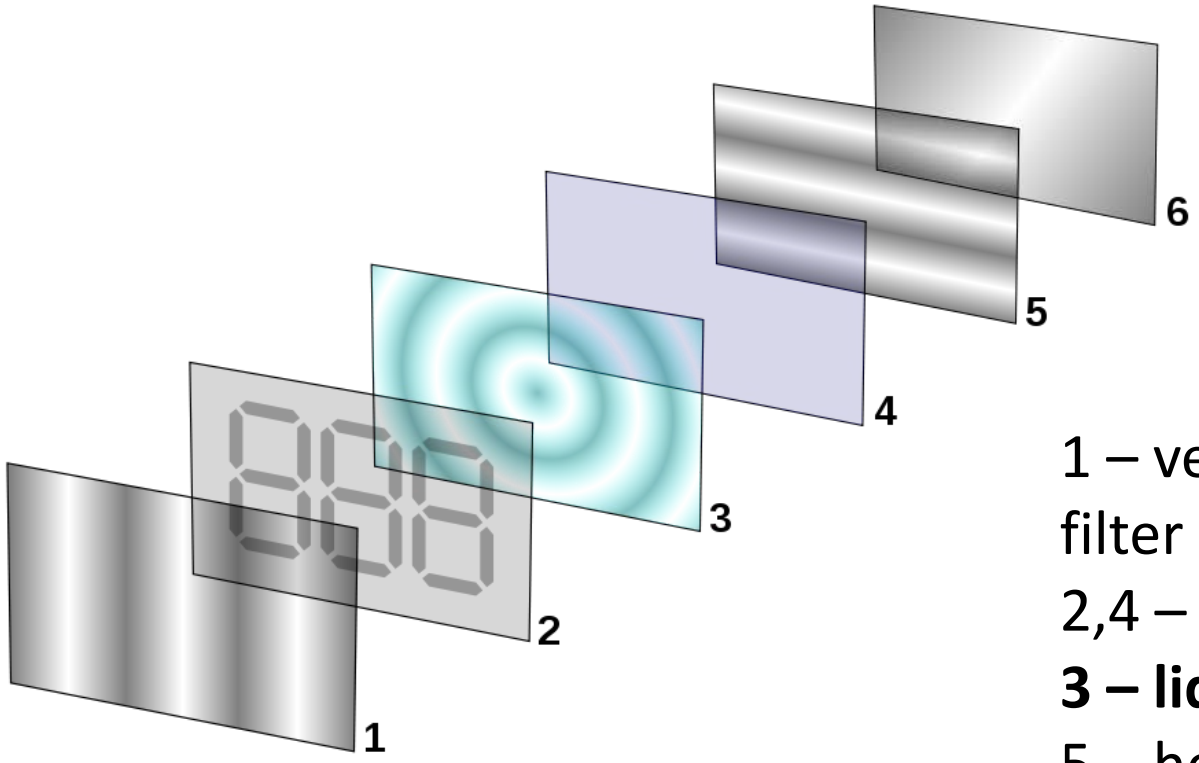
Disadvantages of LCP

- Highly anisotropic properties
- Drying required before processing
- High cost

Applications

- LCD displays
- Dyes
- Advanced Materials (Kevlar)
- Temperature Measurement
- Drug Delivery
- Automotive Applications
- Parts, Engineering
- Food Containers
- Electrical Appliances

Applications : LCP in Display Monitors



1 – vertical polarization filter
2,4 – glass with electrodes
3 – liquid crystal polymers
5 – horizontal polarization filter
6 – reflector

Applications : In defense for making armours

- When liquid crystal polymers solidify, the liquid crystal structure ‘freeze in’
- This results in materials of high tensile strength & in some cases unusual electro-optical behaviour
- e.g. Kevlar aramid fibre
  - bullet-proof vest
  - airplane bodies (aromatic polyamide)

References:

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THANK YOU ☺