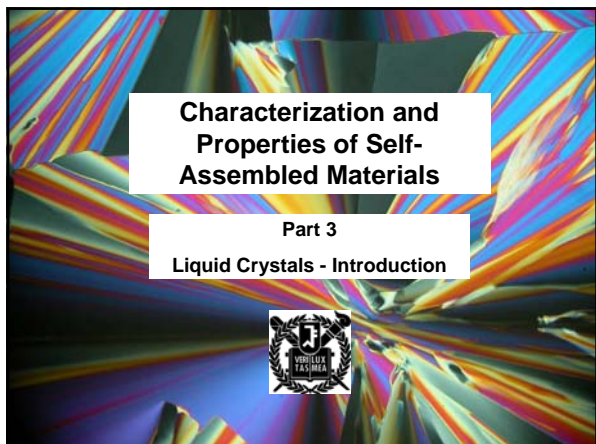





Characterization and Properties of Self-Assembled Materials

Part 3

Liquid Crystals - Introduction

Examples of Liquid Crystal Compounds (Mesogens)

Rod-like
 octyl cyanobiphenyl (8CB)
 positive dielectric anisotropy
 (e.g. for twisted nematic (TN) display)

CCCCCCCCc1ccc(cc1)C#N

Side-chain LC polymer

CH3-Si(CH3)2-O-C6H10-C6H4-C#N

Main-chain LC polymer (Kevlar)

c1ccc(cc1NC(=O)c2ccc(cc2C(=O)N)

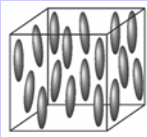
Discotic (Hexahexyl triphenylene)

CCCCCc1ccc2c(c1)ccc3c2C(C)C(C)C3

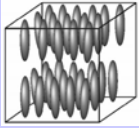
negative dielectric anisotropy
 (e.g. for vertically aligned (VA) display)

CCCCOc1ccc(cc1)OC(=O)c2ccc(cc2)CCCC

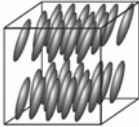
Common Liquid Crystal Phases



Nematic



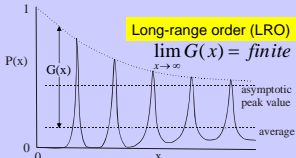
Smectic A



Smectic C

Long-range order (LRO)

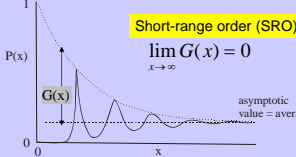
$\lim_{x \rightarrow \infty} G(x) = \text{finite}$



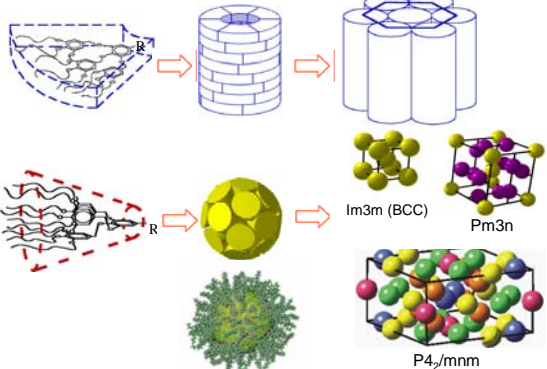
Probability function:
 $P(x)$ = probability that the centre of an object is at x (**positional order**)
 = probability that object is oriented parallel to unique axis (**orientational order**)

Short-range order (SRO)

$\lim_{x \rightarrow \infty} G(x) = 0$

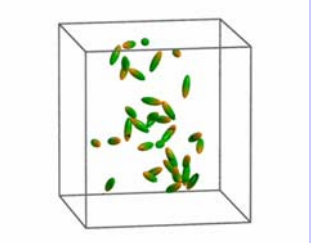


Correlation function:
 $G(x) = P(x) - \text{average}$



from: Ungar & Zeng, *Soft Matter*, 2005, 1, 95-106

Particle Dynamics Simulation of Spherical Self-Assembly



Courtesy of Dr Doug Cleaver, Sheffield Hallam Univ.



Cubic LC ("Double Diamond")
– Aromatic networks of "rods", aliphatic continuum

Length = 2 molecules

Place of Liquid Crystals between crystal and liquid

Phase		Dimensionality of positional LRO*	Dimensionality of orientational LRO	Comment
Isotropic liquid		0	0	
Nematic	uniaxial	0	1	unconfirmed
	(biaxial) ?		3	
Smectic	A	1	1	<i>n</i> normal to layers
	C		3	<i>n</i> tilted
	B (Hexatic)		1	<i>n</i> normal
	F ₁ (Hexatic)		3	<i>n</i> tilted
Columnar	hexagonal	2	1	different plane group symmetries
	rectangular		1,3	
	oblique		1,3	
3-D	cubic	3	3	different space-group symmetries
	hexagonal			
	tetragonal			
Crystal		3	3	molecules have preferred positions

LC

When is a 3d structure a crystal, and when a LC?

- In a crystal a molecule (its centre of gravity), has a preferred position in a unit cell.
 - this does not mean that all atoms have a preferred position!
 - e.g. plastic, or orientationally disordered crystals
 - sharp Bragg X-ray diffraction peaks in the wide-angle range (around 3-5Å range)
- In a LC only domains (e.g. aromatic, aliphatic, polar) have preferred positions, but not individual molecules
 - only diffuse scattering in wide angle diffraction range

Liquid crystals:

- Thermotropic
 - no solvent involved
 - phase transitions induced by temperature
 - (all LCs in LCD)
- Lytotropic
 - involves a solvent, usually water
 - examples:
 - soap in water
 - lipids in water (lipid bilayers form cell membranes)