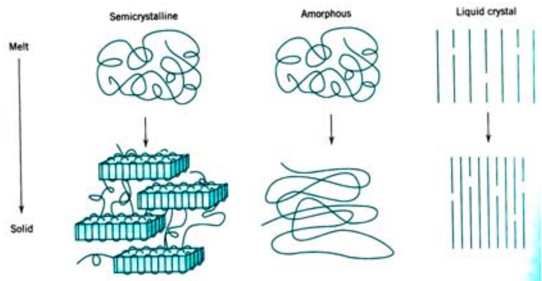
Liquid Crystals

Typically composed of extended, rod-shape, and rigid molecules

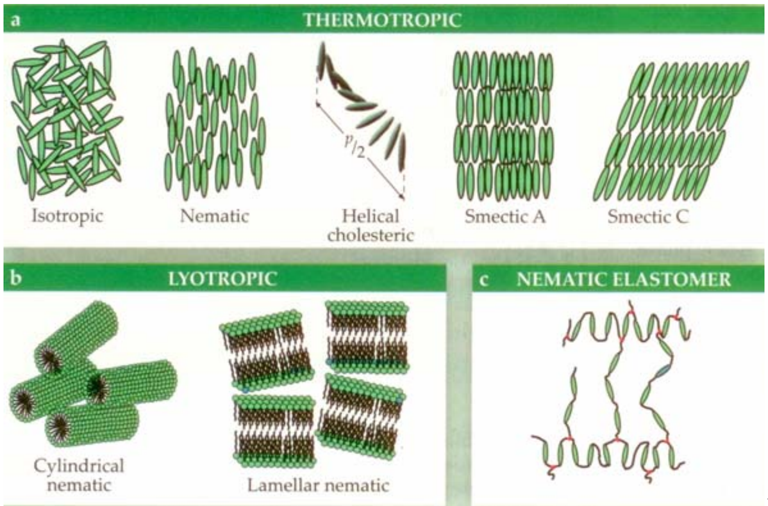
Neither crystalline, nor liquid

Alignment exist in the melt, molecular alignment remains plus additional domain structure (with characteristic intermolecular spacing)



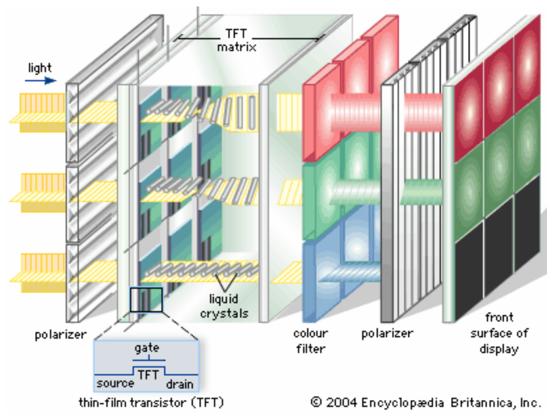
Structures of various LC phases

VdW forces (due to anisotropic molecular polarizability) give rise to parallel alignment



Liquid Crystal Displays

Based on the property to align polymer molecules with the electric field
Twisted nematic cell: fluid liquids, transparent, optically anisotropic at RT
It serves as a light shutter by rotating or not rotating the plane of polarization



This varying orientation in turn varies the amount of light allowed to pass through the TFT matrix and colour filter, thereby changing the colour picture on the display screen

Conductive Polymers

Polyacetylene: can be conductive almost like a metal

The halogen doping transforms polyacetylene to a good conductor (*p*-doping).
Reductive doping (called *n*-doping) is also possible using, *e.g.,* an alkali metal.

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http://nobelprize.org/nobel_prizes/chemistry/laureates/2000/chemadv.pdf

Mechanism of polymer conductivity – role of doping

The role of the dopant is either to remove or to add electrons to the polymer

The produced radical cation (also called a ”**polaron**”) is localized, partly because of Coulomb attraction to its counterion (I_3^-), which has normally a very low mobility

Bipolarons

•If a second e is removed from an already-oxidised section of the polymer, either a second independent polaron may be created or, if it is the unpaired electron of the first polaron that is removed, a **bipolaron** is formed

•The two “+” charges of the bipolaron are not independent, but move as a pair

Intersoliton hopping (between chains)

Bulk conductivity in the polymer material is limited by the need for the electrons to jump from one chain to the next, *i.e.*, in molecular terms an intermolecular charge transfer reaction

Inter-soliton hopping: charged **solitons** (bottom) are trapped by dopant counterions, while neutral solitons (top) are free to move. A neutral soliton on a chain close to one with a charged soliton can interact: the electron hops from one defect to the other

Additives

- Fillers
 - improve mechanical property
 - wood, sand, glass, clay
 - reduce cost
- Plasticizers
 - improve flexibility and toughness, small molecules will incorporate between the chains; typically liquids
- Stabilizers
 - improve deteriorative resistance (no degradation with T, light, chemicals)
 - UV coatings
- Colourants
 - dyes (dissolve); - pigments (phase separate)
- Flame Retardents
 - releasing non-flammable gas
 - will break down endothermically at high temperature

Soft Reactive Adhesives

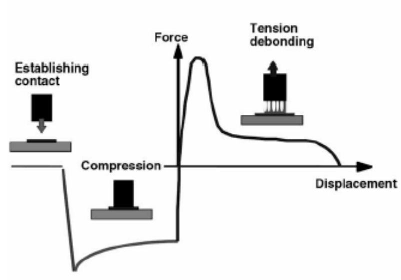
- Soft polymer materials (polyurethanes, polysiloxanes): designed to be further cross-linked through external activation (heat, H_2O vapours, oxygen, UV-visible radiation)

- radical chain polymerization
- stepwise polymerization

Pressure-Sensitive Adhesives

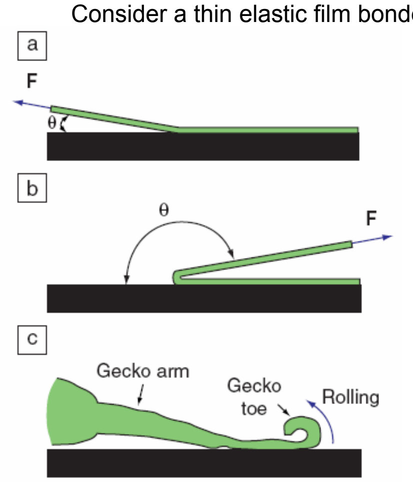
Self-adhesive materials are called, in the adhesives trade, "**pressure-sensitive adhesives**" (PSAs)

Material requirements:



Attachment and Detachment

Consider a thin elastic film bonded to a flat substrate



Summary

1. Describe various polymerization reactions and steps
2. Polymer structure
3. The glass transition temperature and changes to the polymer structure around this temperature
4. Explain deformation steps, strengthening mechanisms and fracture mechanisms in polymers

Problems

11.1 If a type of polyethylene has an average degree of polymerization of 10,000, what is its average molecular weight?

11.2 An ABS copolymer consists of 25 wt % polyacrylonitrile, 30 wt % polybutadiene, and 45 wt % polystyrene. Calculate the mole fraction of each component in this material.

11.3 How much sulfur must be added to 70 g of butadiene rubber to cross-link 3.0 percent of the mers? (Assume all sulfur is used to cross-link the mers and that only one sulfur atom is involved in each cross-linking bond.)

11.4 A stress of 9.0 MPa is applied to an elastomeric material at a constant stress at 20ºC. After 25 days, the stress decreases to 6.0 MPa. (a) What is the relaxation time τ for this material? (b) What will be the stress after 50 days?

11.5 Write a general chemical reaction for the chain polymerization of ethylene monomer into the linear polymer polyethylene.

11.6 What is the function of the initiator catalyst for chain polymerization? How is it possible for a polymer chain such as a polyethylene one to keep growing spontaneously during polymerization? What are two methods by which a linear chain polymerization reaction can be terminated?

11.7 Write structural formulas for the mers of the following vinyl polymers: (a) polyethylene, (b) polyvinyl chloride, (c) polypropylene, (d) polystyrene, (e) polyacrylonitrile, and (f) polyvinyl acetate.

11.8 How does the amount of crystallinity in a thermoplastic affect (a) its density and (b) its tensile strength? Explain.

11.9 Why is the use of a stereospecific catalyst in the polymerization of polypropylene so important?