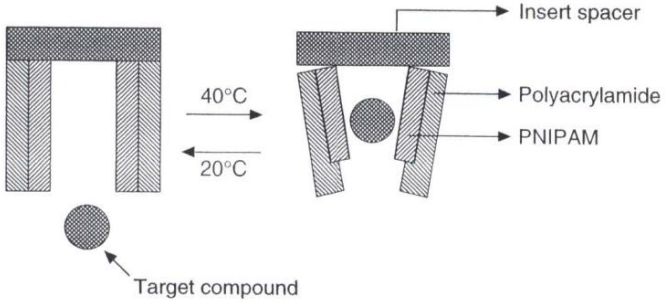
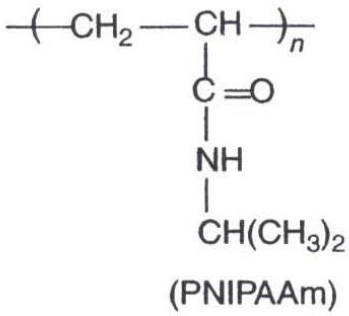
Hydrogels

- crosslinked hydrophilic polymers
- superabsorbent polymers [SAP]
  - PAA, PAAm, PVA
  - irrigation, fertilizer retention, diapers
- stimuli-sensitive [smart] hydrogels
  - temperature-sensitive
    - PNIPAAm, copolymers with vinyl ethers, acrylates
      - (controllable) LCST
      - crosslinked (swell-deswell) or linear (sol-gel)
    - actuators

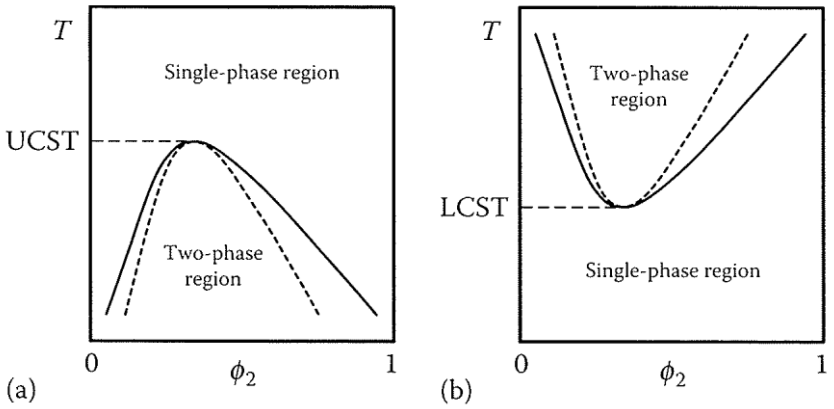


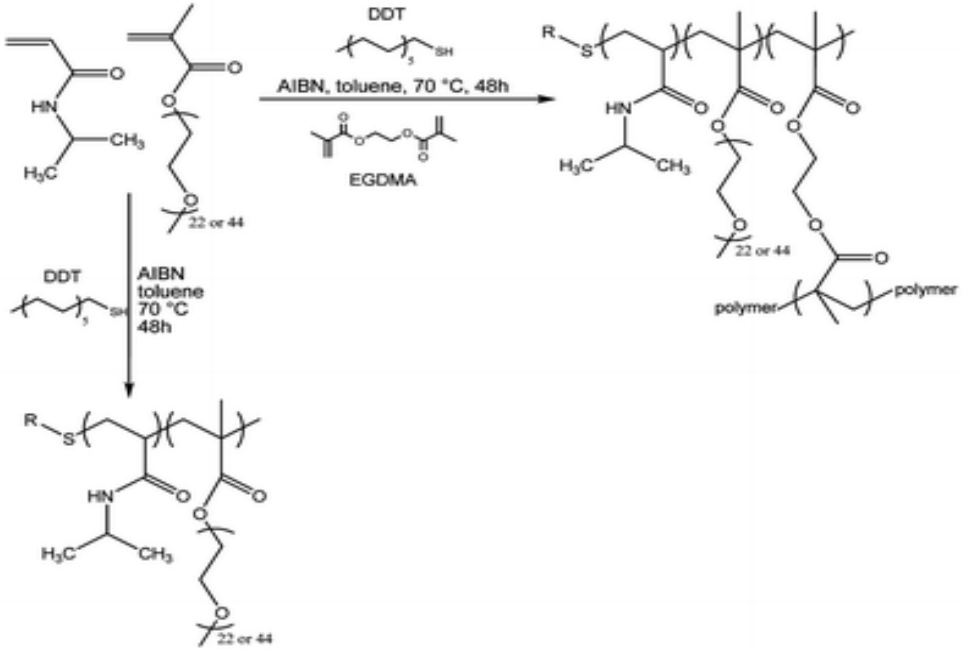


(PNIPAAm)

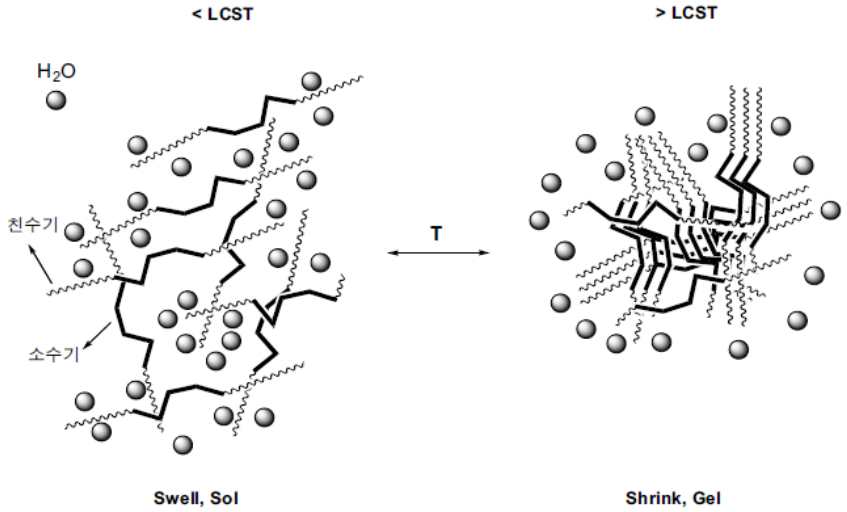
Microgel

- micron-size crosslinked polymer
- temperature-sensitive microgel
  - water-insoluble at polym'n Temp > LCST ~ deswell
  - water-soluble at lower Temp < LCST ~ swell
  - eg, pNIPAAm ~ useful in drug delivery

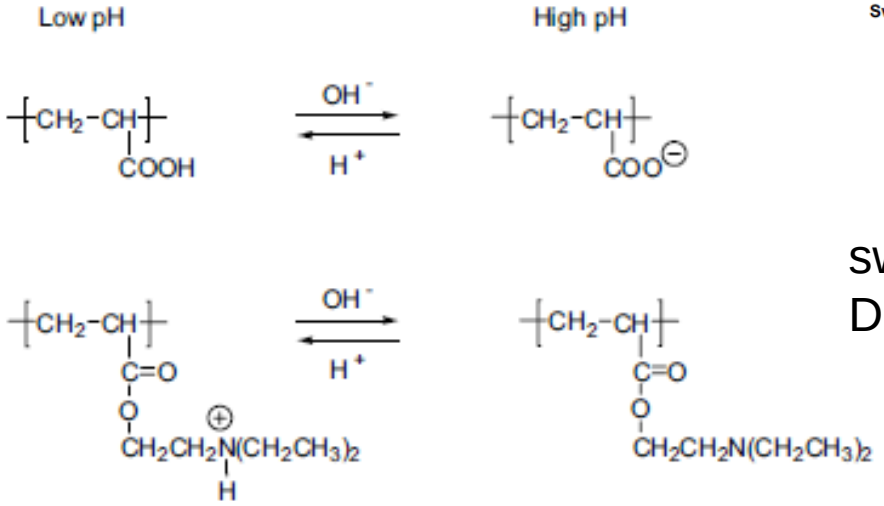




- DDS



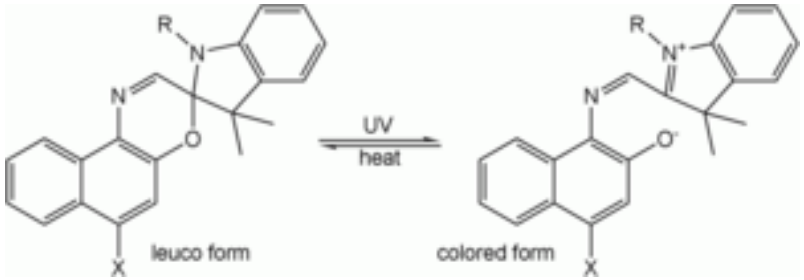
- pH-sensitive



swell-deswell by ionic repulsion
Different pH in stomach and gut

- DDS, biosensor

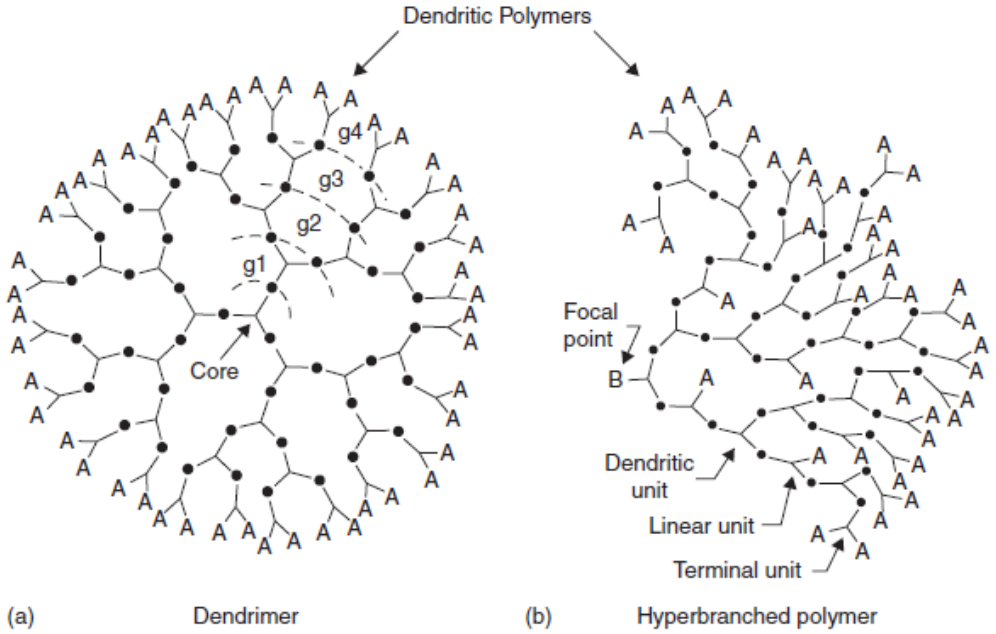
- light-sensitive
  - UV sensitive ~ leuco dyes
  - vis sensitive ~ Fig 5.76
    - by heating



- electric field-sensitive
  - PAN, PAAm, PMA, ---
  - swell-deswell, bending by
    - E-produced stress
    - ion movement
  - actuator, switch

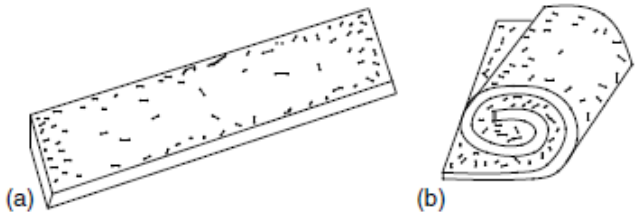
Dendritic polymers

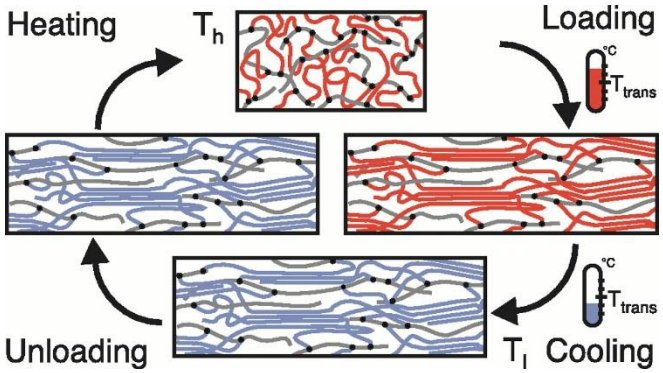
- dendrimer vs hyperbranched polymers
  - dendrimer ~ multi-generation, monodisperse, uniform
  - HBP ~ one-step, polydisperse, defects
- properties
  - density gradient
  - low viscosity
  - high functionality
- applications
  - DDS
  - rheology modifier
  - catalyst, ---

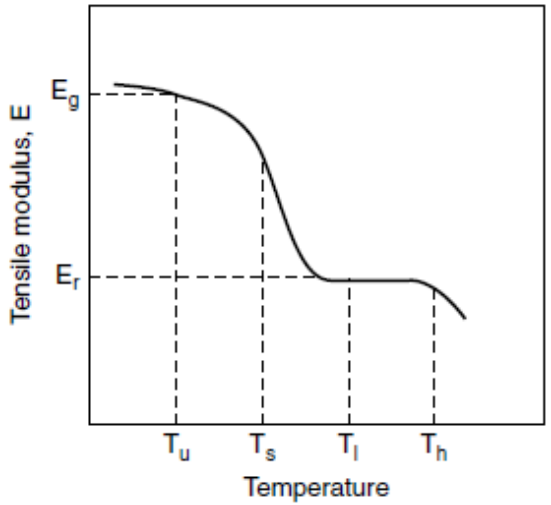


Shape-memory polymers

- frozen phase (fixed point) + reversible phase
  - TPI ~ crosslinks + TPI crystals
  - SB polymer ~ S domain + BD domain
  - PU ~ hard segment + soft segment
- large E_g/E_r preferred
- packaging, sensor, biomedical







Microencapsulation

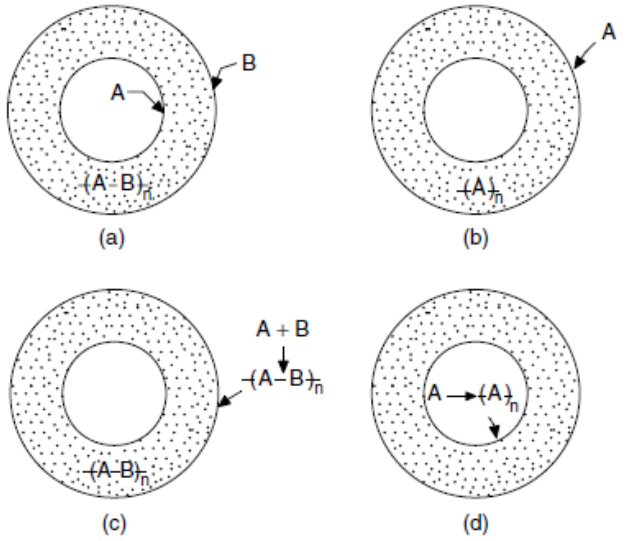
- enveloped by using
  - coacervation ~ two (water-soluble) polymers in colloid
    - coacervate (high polymer conc'n) + supernatant (low)
    - coacervate with substance crosslinked
  - polymer-polymer incompatibility ~ one polymer
    - two polymers in solvent → phase-separated
    - substance engulfed by one polymer
  - interfacial a/o in-situ polymerization

    (a) interfacial polym'n, substance in core

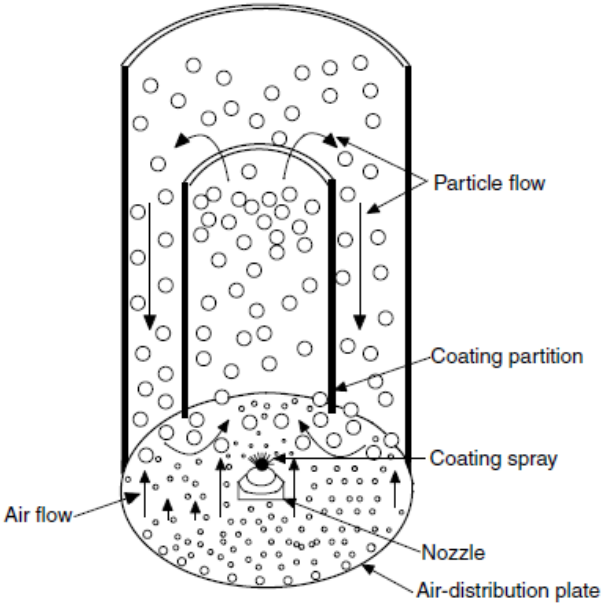
    (b) in-situ polym'n, initiator in core

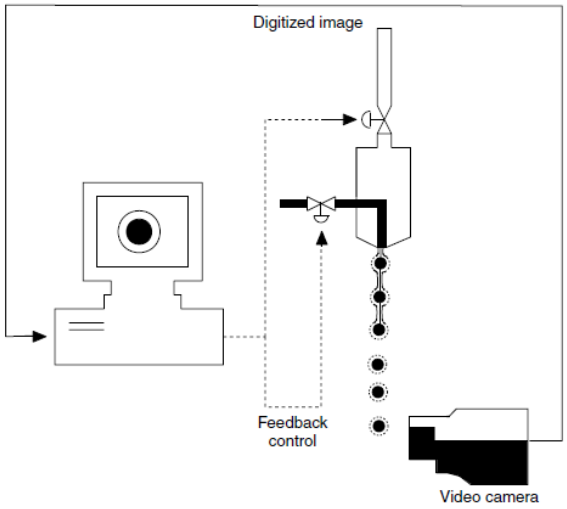
    (c) polym'n and moves to interface

    (d) polym'n in core and moves

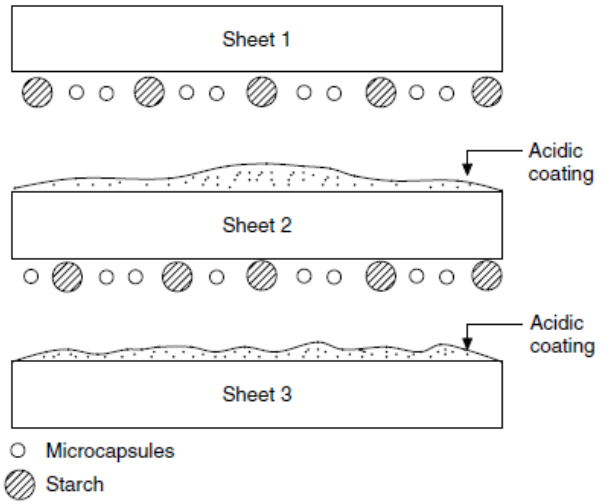


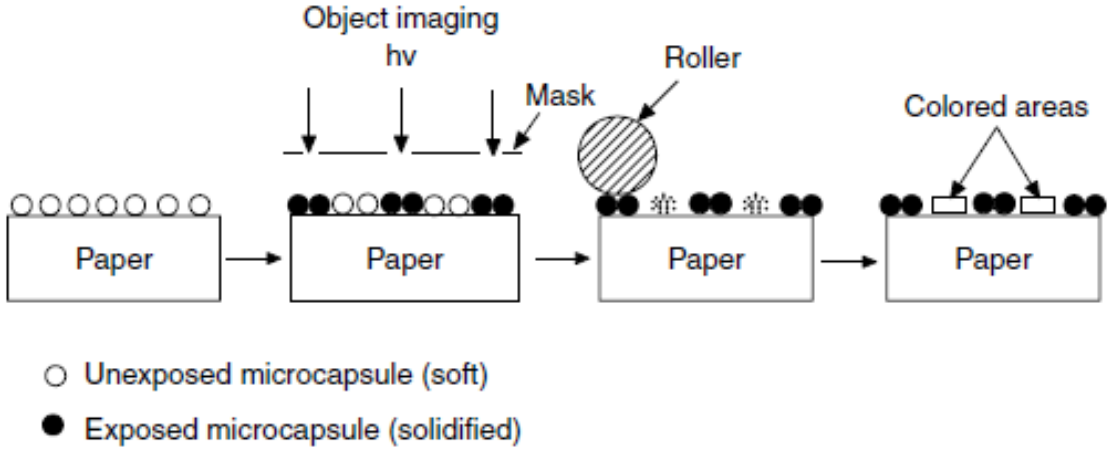
- enveloped by using (cont'd)
  - spray drying ~ cheap
    - (oil+substance) in water sprayed to hot chamber
  - fluidized-bed coating
    - for solid or liq-absorbed solid
  - co-extrusion
    - through concentric orifice





- released by
  - rupture (perfume, copy, printing)
  - dissolution (detergent)
  - melting (food)
  - diffusion (medicine)
  - biodegradation (medicine)

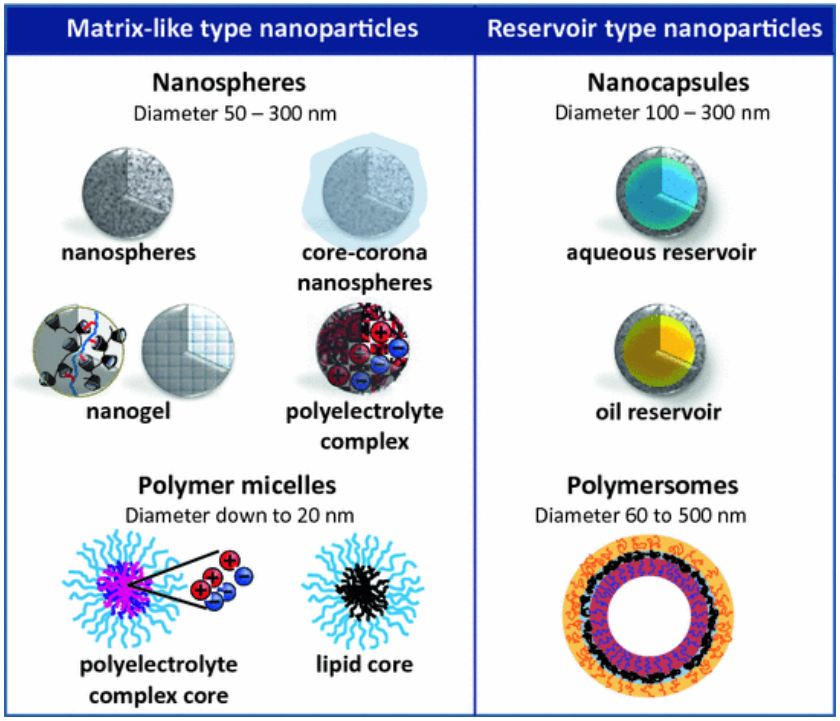


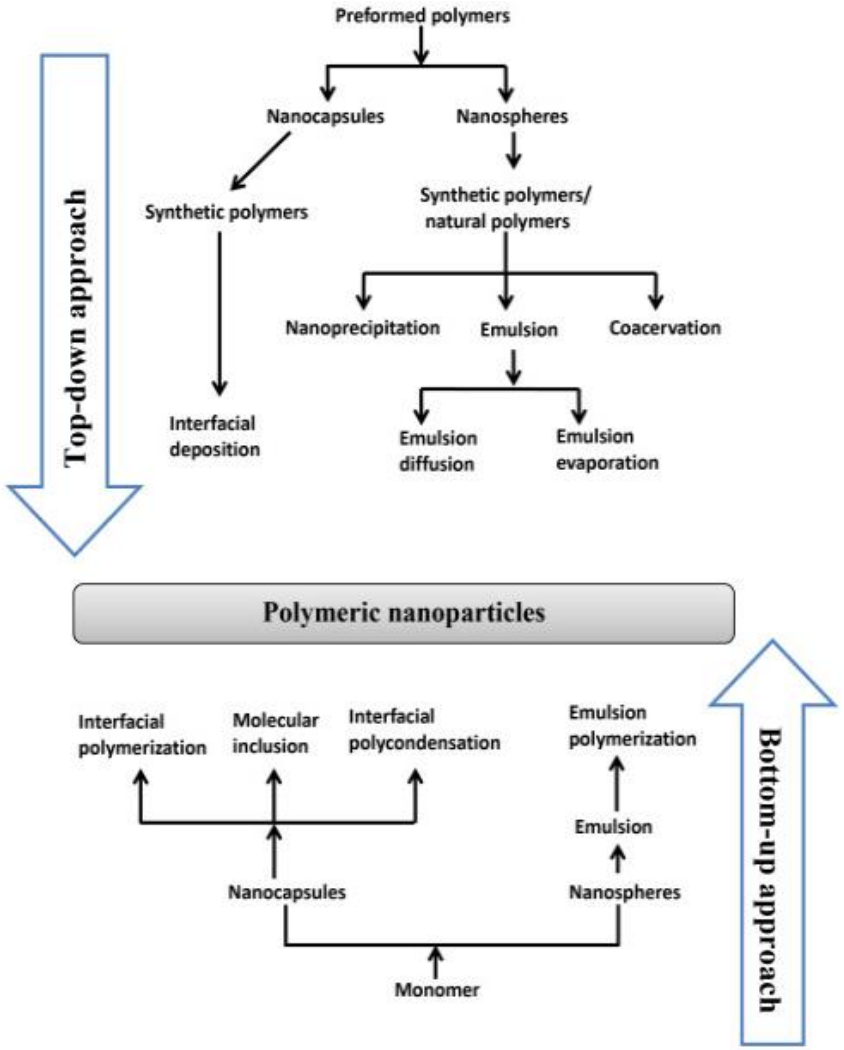


Nano-sized polymers

- nano < 100 nm ~ high surface area

- nanoparticles
  - nanospheres ~ RP
  - nanocapsules ~ DD





- nanofibers
  - electrospun
  - for reinforcing, membrane, tissue engineering
- other nanostructures
  - nanowires, nanofilms, nanotubes, nanorods
  - electronic, optical, medical applications

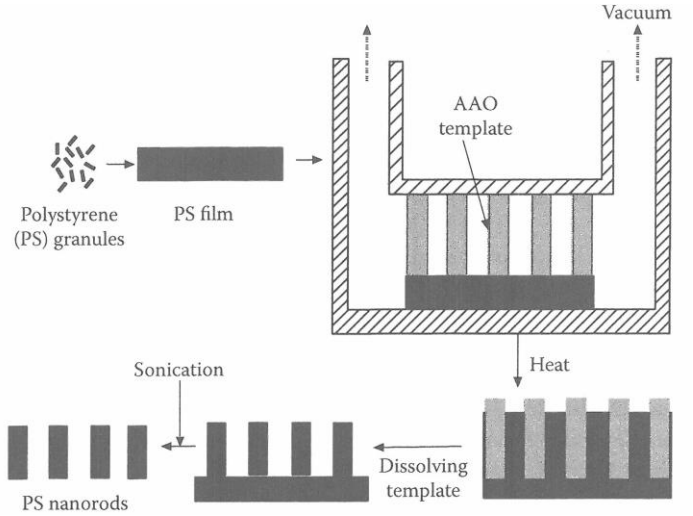
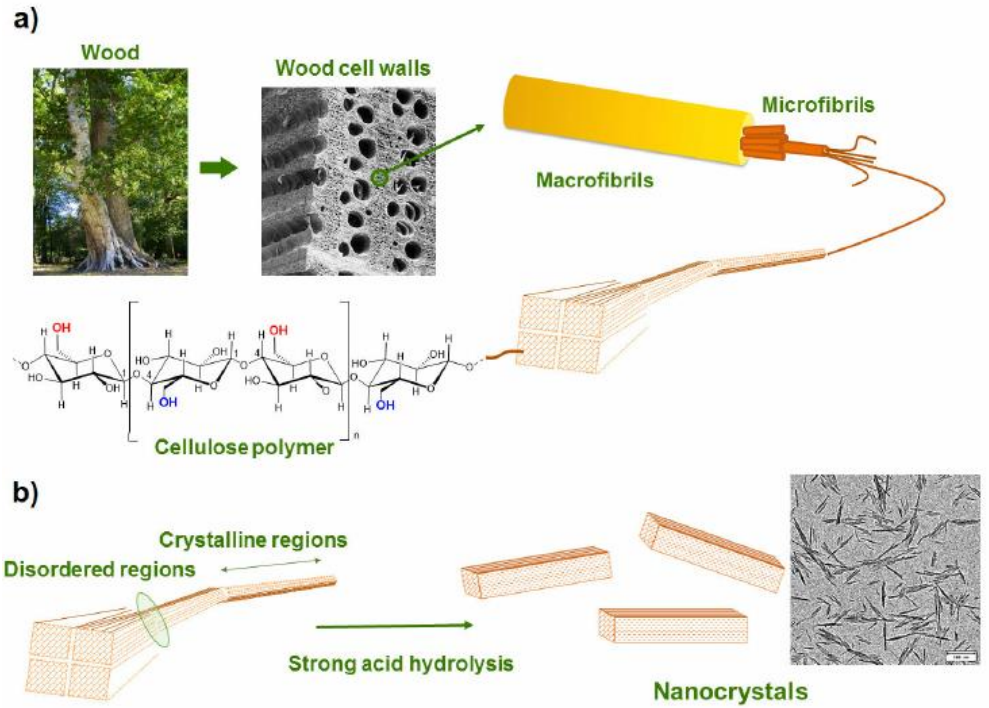


Fig 5.95

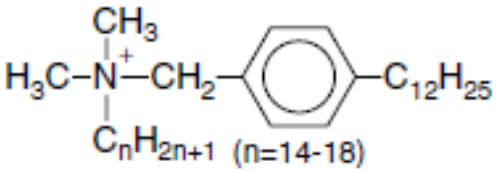
- nanocellulose
  - cellulose nanofiber [CNF], cellulose nanocrystal [CNC]
  - grinding and hydrolyze pulp
  - for reinforced plastics
    - E = 167 GPa

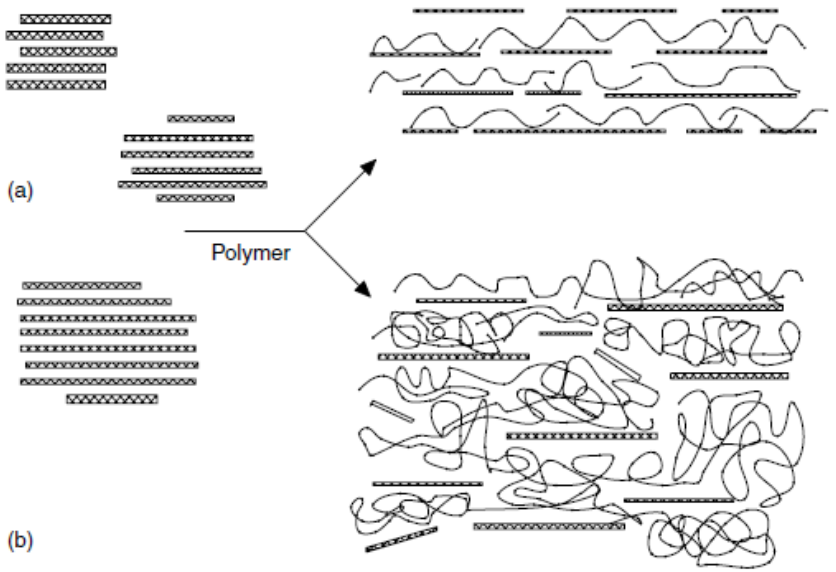


Polymer nanocomposites

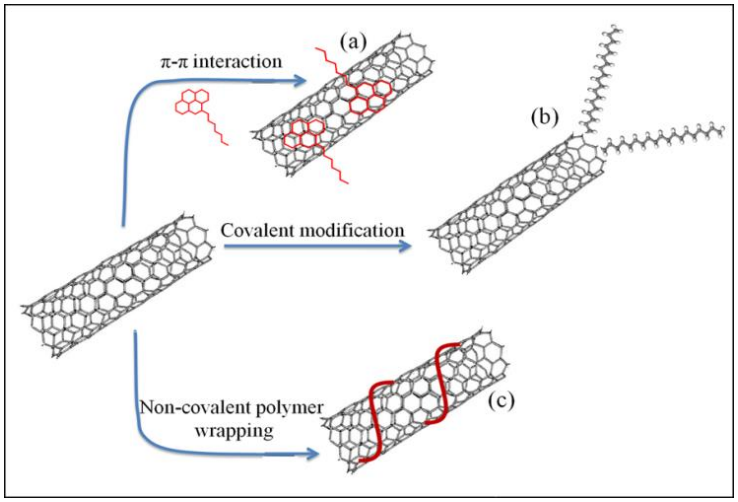
- polymer matrix + nanoscale (< 100 nm) inclusion
- compared to macro- or micro-composites
  - NC has
    - larger interfacial area
    - smaller inter-particle distance ~ larger interaction
    - at smaller weight fraction (< 10 wt%)
  - giving higher
    - modulus, strength
    - heat resistance
    - wear resistance
    - barrier property, flame retardancy
    - optical transparency
    - processability

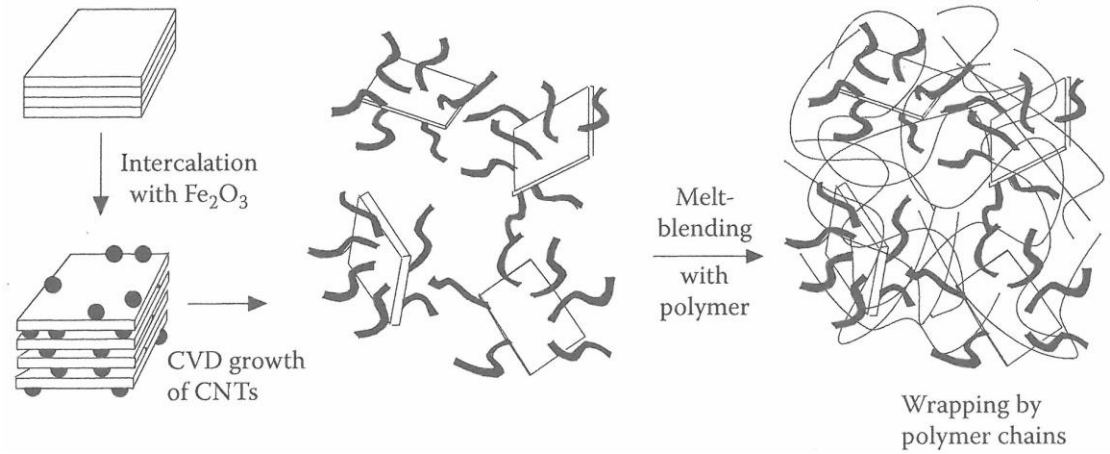
- polymer/clay NC
  - (nano)clay ~ layered silicate ~ Na-MMT
  - need organic modification ~ organoclay
    - especially for non-polar polymers
    - with compatibilizing intercalant
  - mixed with polymer by
    - melt mixing
    - solution mixing
    - intercalation/polymerization
  - giving
    - intercalated or
    - exfoliated morphology





- polymer/CNT NC
  - smaller (than clay), conductive
  - functionalization for dispersion
  - solution, melt, in-situ also
- polymer/CNT-clay hybrid NC
  - CNT grown on clay ~ hybrid filler





- polymer/graphene NC
  - 2-D, smaller
  - strong, flexible, conductive
  - functionalization for dispersion
  - solution, melt, in-situ also

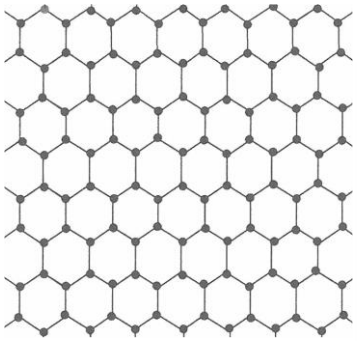
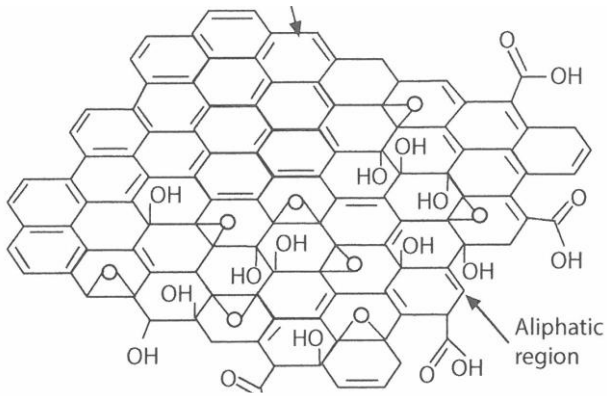
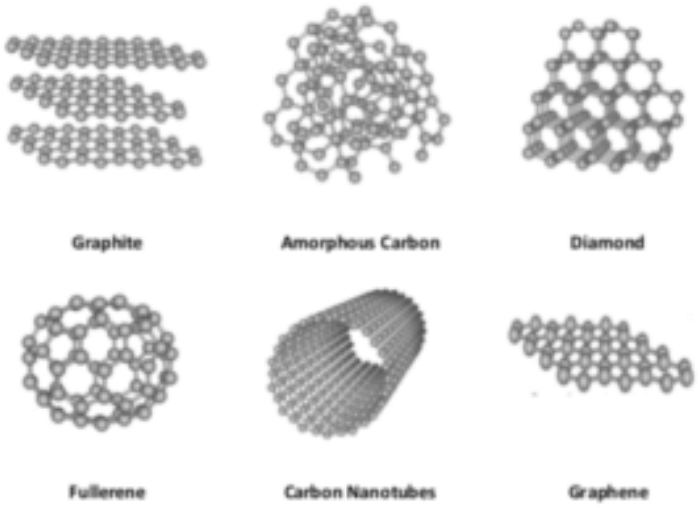


Fig 5.100, 102





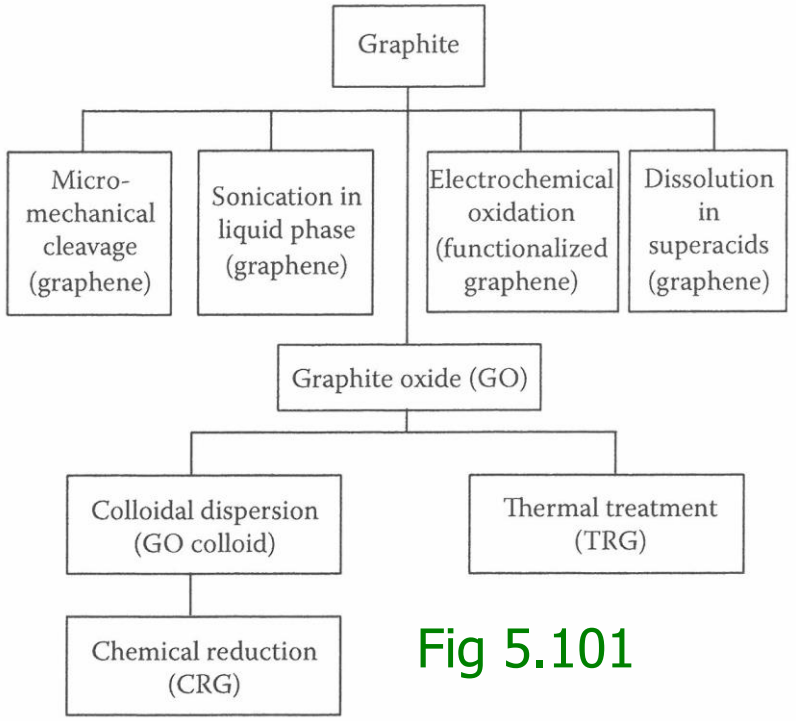
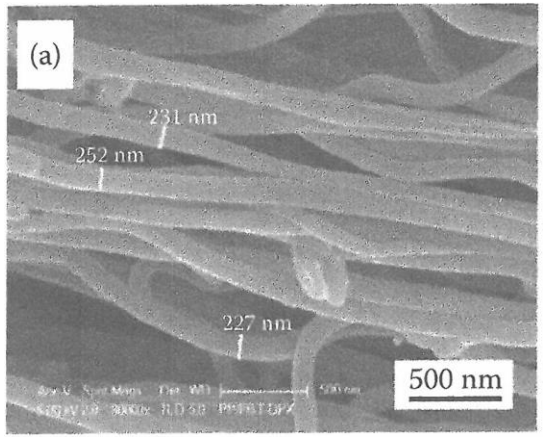
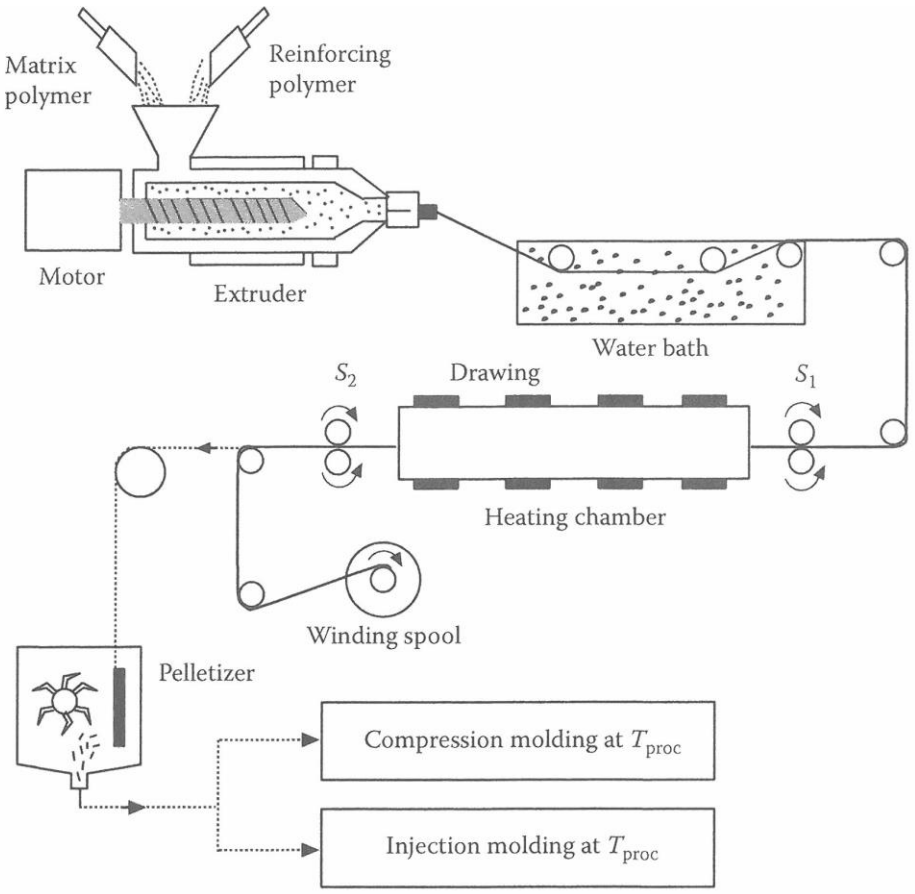


Fig 5.101

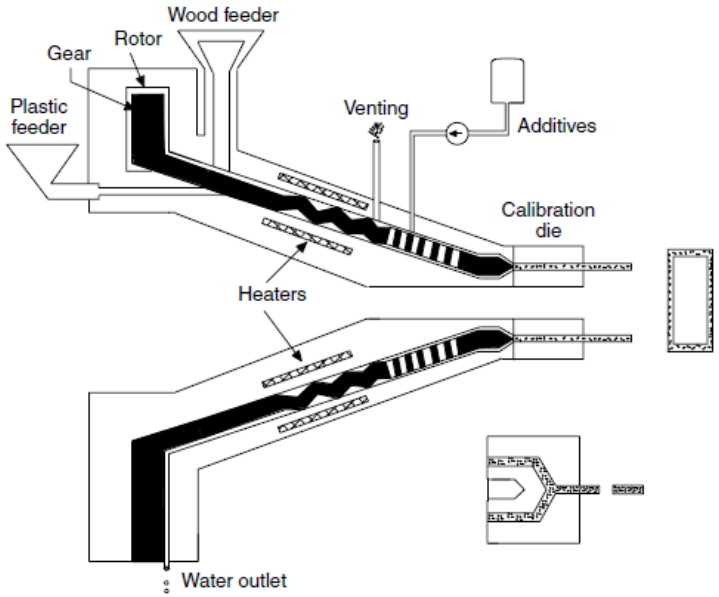
- micro/nanofibrillar polymer composites
  - polymer fibrils in polymer matrix
    - low/high T_m pairs
    - LCP/glassy pairs
  - fibril forms in-situ
  - reinforcing, tissue engineering





Wood-polymer composite

- wood + polymer
  - wood fiber or flour
  - PE, PP, PVC
- environmentally friendly, sensible
- construction, automotive



Polymerization-filled composites

- for highly-filled composite
- polymerization site on the filler