

Chap 20. Plastics

- Contents of plastic compound :

- reinforcing agent
- fillers
- coupling agents
- stabilizers
- pigments
- dyes
- plasticizers
- lubricants
- processing aids
- curing agents
- blowing agent
- flame retardants

- Contents of plastic compound :

1. reinforcing agents – to enhance the structural properties of compound, such as modulus(stiffness), strength, etc.

(e.g) glass fiber

- carbon fiber (pitch, polyacrylonitrile (PAN))

- aramid fiber (aromatic polyamide) - kevlar -

- rubber particles ($\phi = 1\mu\text{m}$) into the polystyrene, to increase toughness or impact strength.

(ex) HIPS (high impact poly),

ABS (acrylonitrile - butadiene - styrene) \rightarrow SAN (styrene - acrylonitrile) copolymer + butadiene or poly(butadiene co acrylonitrile) rubber.

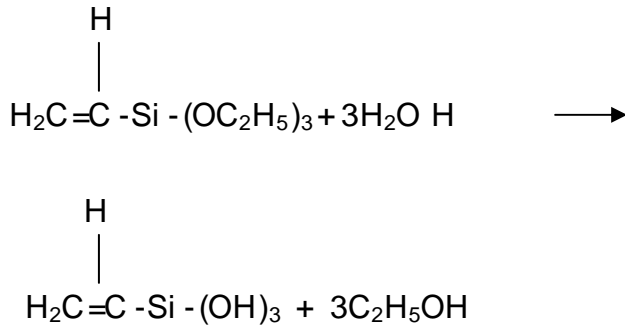
2. fillers :

(e.g) atactic - polypropylene into the talc.

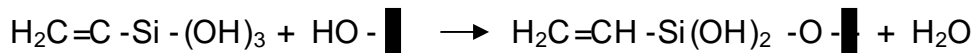
TiO_2 into the Nylon, etc.

3. coupling agents :

- most inorganics have hydrophilic surfaces (-OH).
- polymers are hydrophobic – so interfacial adhesion is often poor.
- To increase adhesion between polymers and fillers.
- Silanes : (step1) Hydrolysis :



(step3)

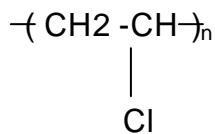


- by converting hydrophilic surface to a hydrophobic surface, compatibility with the polymer is improved.
- also styrene-butadiene blockcopolymer could be a compatibilizing agent in the blend system polystyrene and polybutadiene.

4. Stabilizer

• inhibits degradation of the polymer, usually as a result of environmental exposure to oxygen or ultraviolet radiation of the polymer

(e.g) PVC ← metal oxide



5. Pigments:

(e,g) carbon black -stabilizer(prevents degradation)
titanium dioxide - common pigment where a brilliant, opaque white is desired.

6. Dyes :

- dyes are colored organic chemicals that dissolves in the polymer.

7. Plasticizers :

- to reduce brittleness

(e,g) PVC+dioctyl phthalate

- addition of a low-molecular weight organic plasticizer to a normally glassy polymer will reduce its modulus by lowering Tg of the compound:

$$\text{(ex) } \frac{1}{T_g} = \frac{w_1}{T_{g_1}} + \frac{w_2}{T_{g_2}} \text{ (Fox eq.)}$$

or $T_g = w_1 T_{g_1} + w_2 T_{g_2}$ (Wood eq.)

where w_1 : weight fraction of component 1

T_{g_1} : glass transition temp of component 1

T_g : glass transition of mixture.

8. Lubricants :

- to produce smoother extrudates and molded articles, and minimize sticking in the mold by acting as mold release agents.

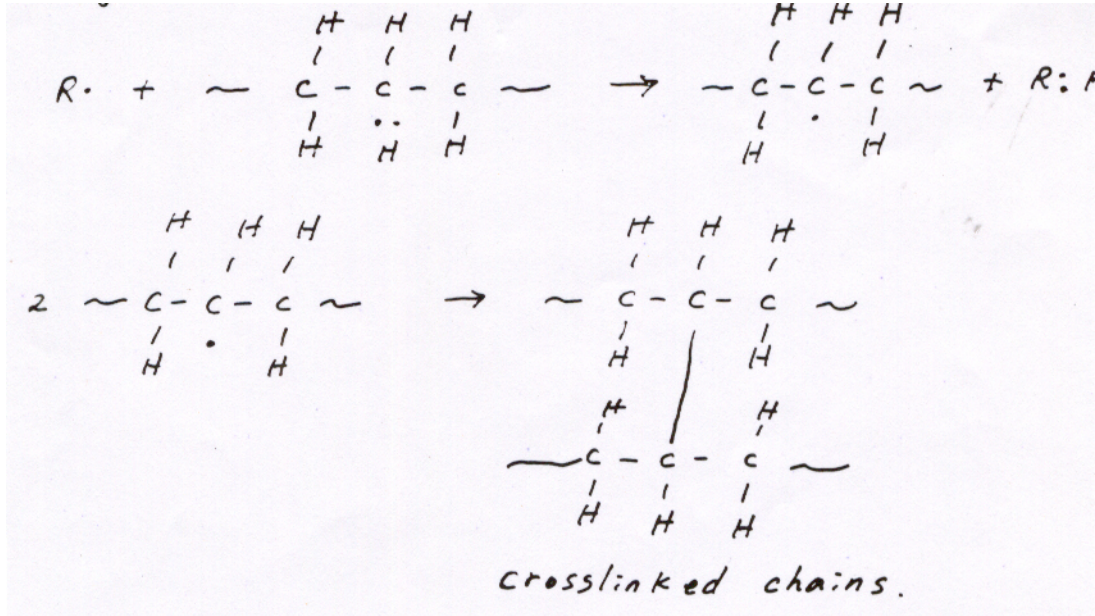
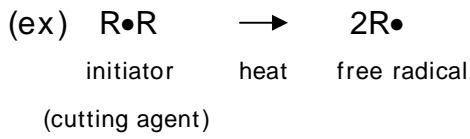
- external lubricants – stearic acid and its metal salt.
- internal lubricants – soluble in the polymer.

9. processing aids :

- to provide higher output, better surface of finish, and easier handling in general.

10.curing agents :

- to produce a crosslinked, thermosetting plastic from an initially linear or branched polymer.

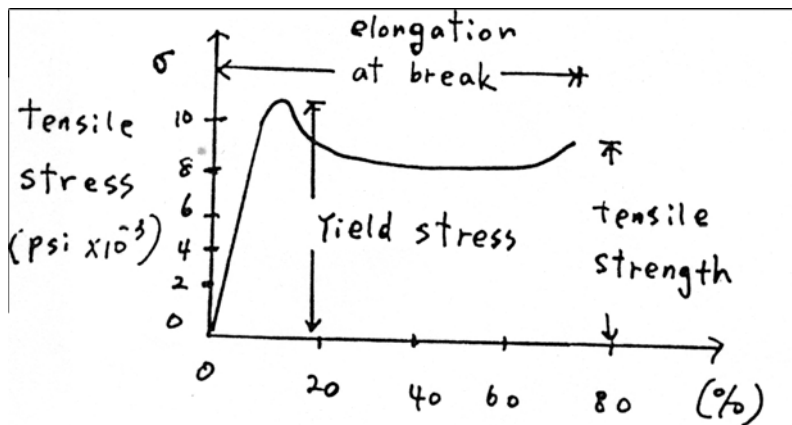


(polyethylene is crosslinked with dicumyl peroxide, converting it from a thermoplastic to a thermoset with much greater heat resistance and resistance to stress cracking and abrasion.)

- Simple elongation of polymers

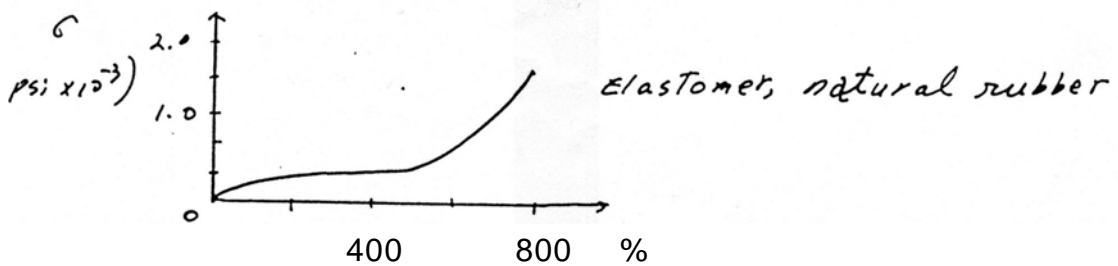
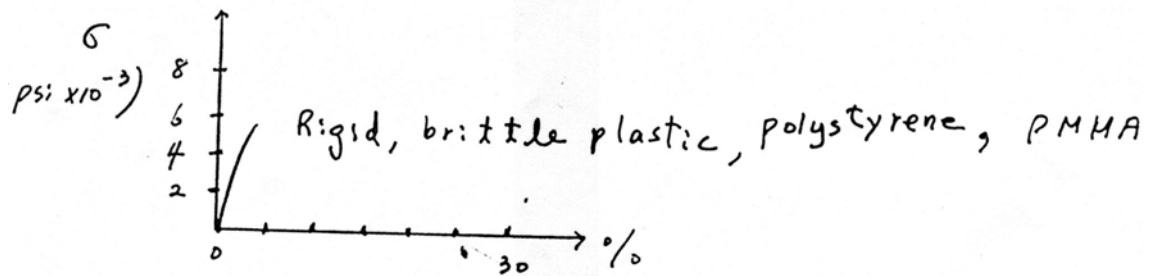
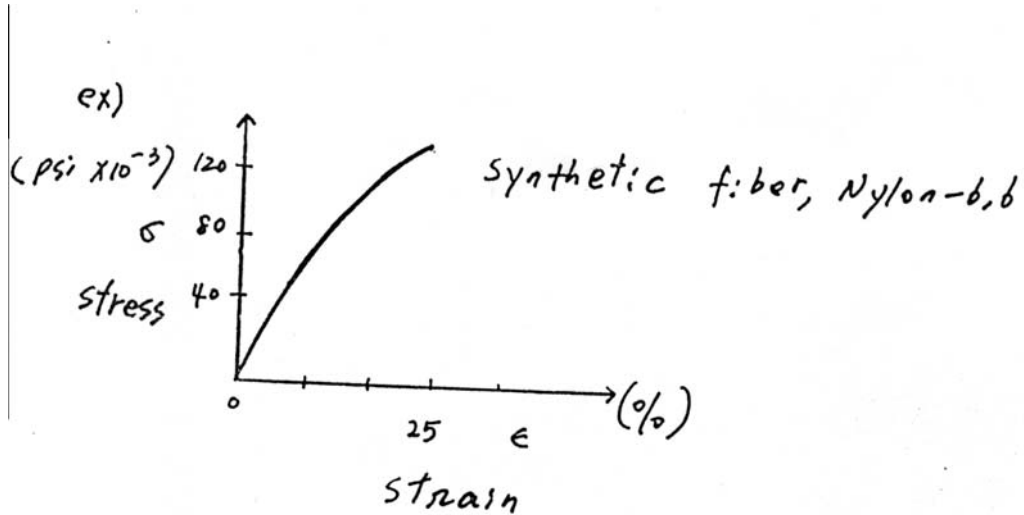
- characteristics of tensile stress-strain curves of polymer samples.

ex) Nylon -66, through plastic



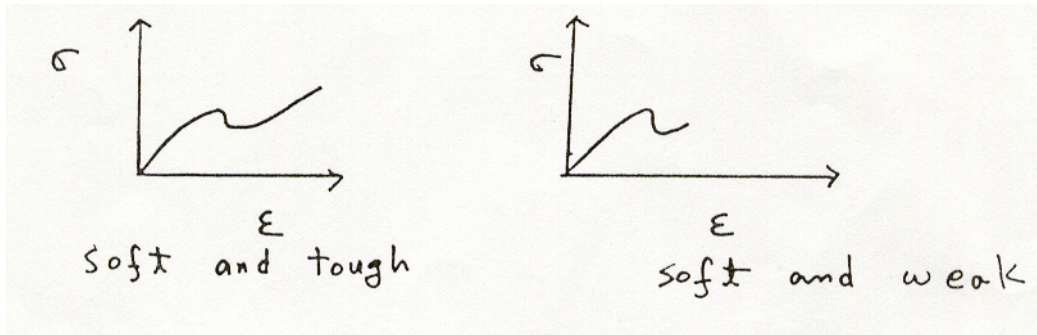
- yield stress : 11000psi
- strain at yield : 15 %
- ultimate elongation : 80 %

ex)



- nonpolar polymer : PE, Teflon $-(CF_2 - CF_2)_n$

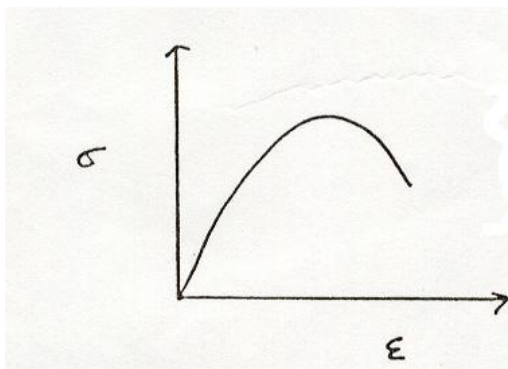
- low modulus, great ductibility (toughness)



: polymer chain dipole-dipole interaction soft .

- strongly polar polymers : nylon, polycarbonate , acetal, etc (engineering plastics)

- stiffness, strength
- hard and strong.



- very high stiffness – filled thermosetting polymers 4~5 (compare to the engineering plastics)

- high modulus, high strength (carbon fiber, thermoset resin, aramid fiber (kevlar): (aromatic polyamide))

11. Blowing Agents:

- foamed plastics must contain a material that generates a gas to produce foaming.

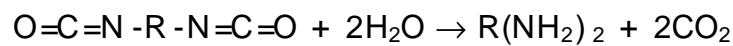
- chemical blowing agents (CBAs) : that generate gas through a chemical reaction.

- physical blowing agents : volatile chemicals that are dissolved in the polymer (CCl₃F)

(ex) polystyrene foam molding beads - pentane is added to the monomer in a suspension polymerization; when a beads are in a mold and heated, the pentane volatilizes , expanding the beads against each other.

(ex) drinking cup, picnic coolers, packaging supports.

(ex) Disocyanate + H₂O → Diamine + 2CO₂



12. Flame Retardants:

- chlorine or bromine, quench the free-radical flame propagation reactions.

(e.g.) tetrabromobisphenol -A in polycarbonate.

tetrabromophthalic anhydride in polyester.