

## Chapter. 21

- Rubber :

- a material that can be stretched to at least twice its original length.
- have a high molecular weight, since rubber elasticity is due to the uncoiling and coiling of long chains.
- : above its glass transition temp.(T<sub>g</sub>).
- must be amorphous : in its unstretched state.
- the polymer be crosslinked : if not, the chains would slip past one another under stress and recovery would be incomplete. (the requirement for crosslinking- covalent bonding between chains).(double bonds that provide sites for vulcanization).

- Thermoplastic Elastomers:

(e.g.) styrene -butadiene -styrene(SBS) block copolymers.

- polystyrene (T<sub>g</sub>≈100°C) is rigid and acts to tie together the long, flexible polybutadiene segments (T<sub>g</sub> is below room temp) as do ordinary crosslinks. But SBS behaves as a true thermoplastic.

- Contents of Rubber Compounds:

1. Reinforcing Agents -

- carbon black basic blacks - hydroxyl groups at the surfaces.  
acid blacks - carboxylic acid.

- particle size, degree of aggregation, surface area, chemical functionality rubber polymer

- cis -1,4 -polyisoprene(natural rubber) and butyl rubber - have reasonable strength without reinforcement: crystallize with molecular orientation at high elongations.

2. Filler -

- to reduce cost.

(e.g.)CaCO<sub>3</sub> - raise the modulus.

3. Extending Oil - hydrocarbon Oils.

- Making the rubber softer and easier to process.
- carbon black and extending oils have opposite effects on the modulus of rubber compound.

4. Vulcanizing or Curing System -

- to crosslink the polymer
- common curing systems are based on sulfur.
  - the formation of sulfide links between chains and the abstraction of protons from adjacent chains to form H<sub>2</sub>S, with the chains crosslinking at the remaining unshared electron

5. Antioxidants or Stabilizer -

- in the unsaturated polymers (butadiene or isoprene), the double bonds are susceptible to attack by oxygen and ozones.

(ex) Tire -tread formulation

Ingredient	Parts by weight
(75/25 butadiene/styrene emulsion copolymer	100
HAF Black	50
zinc oxid	5
stearic acid      promoters	3
sulfur	2
accelerator(Santocure)	0.75
extending oil (Circosol)	10

- promoters : to improve the cure still further.
- accelerator : to speed up vulcanization.

#### 6. Rubber Compounding:

- the ingredients above must be compound with the rubber polymer to produce the final rubber compound for molding, extrusion, etc with either two-roll mill or Banbury mill.