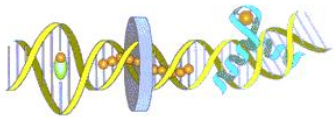
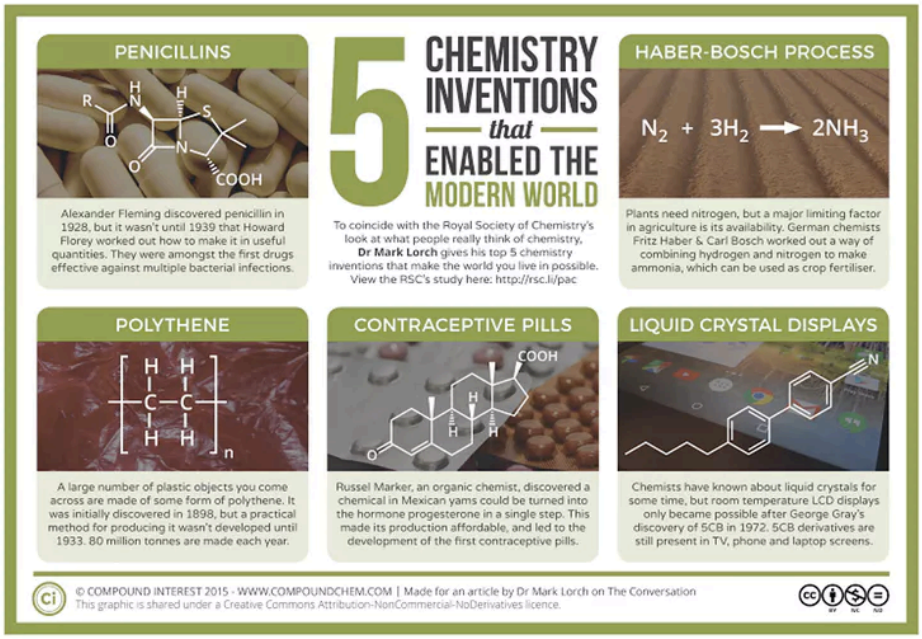
POLYMER SCIENCE and TECHNOLOGY I

Dr. Işıl Gerçek Beşkardeş
2018



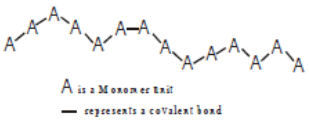
- What is the greatest contribution of chemistry to science and society?

- Development of POLYMERIZATION is one of the biggest inventions chemistry has done, where it had the biggest effect on everyday life.



DEFINITIONS

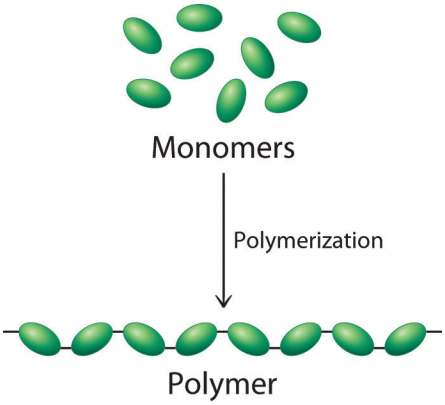
- POLYMER
  POLY+MEROS (in Greek)



- The word polymer means many parts or units.
- Polymers are chain-like structures.
- A polymer is a molecule made up of smaller molecules that are joined together by chemical bonds, in general covalent bonds.

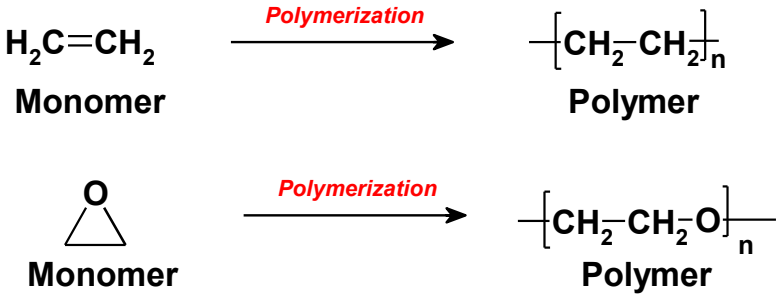
DEFINITIONS

The process by which monomers combine is called **polymerization**



DEFINITIONS

Polymers are large molecules made up of repeating units called Monomers



ADVANTAGES OF POLYMERS

Wide variety

Easy processing

Lightness

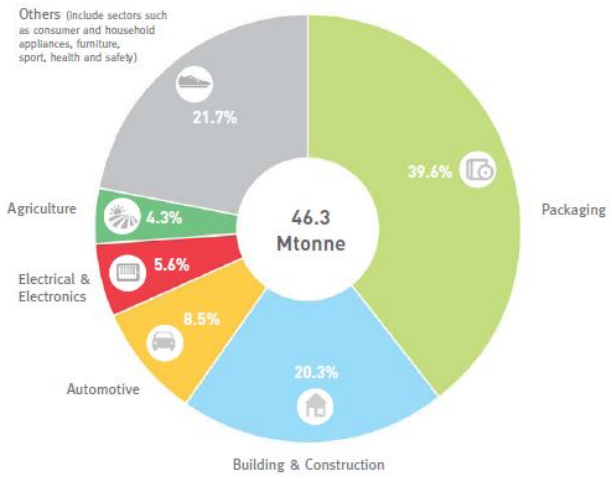
CHARACTERISTICS OF POLYMERS

- Melting point
- Mechanical properties
- Density
- Electrical properties
- Optical properties
- Colorability, solvent sensitivity, flammibility etc.

USES OF POLYMERS

- Packaging materials
- Textile materials
- Transportation
- Industrial materials
- Home furnishing
- Information technologies
- Medical devices
- Pharmaceutical applications, etc.

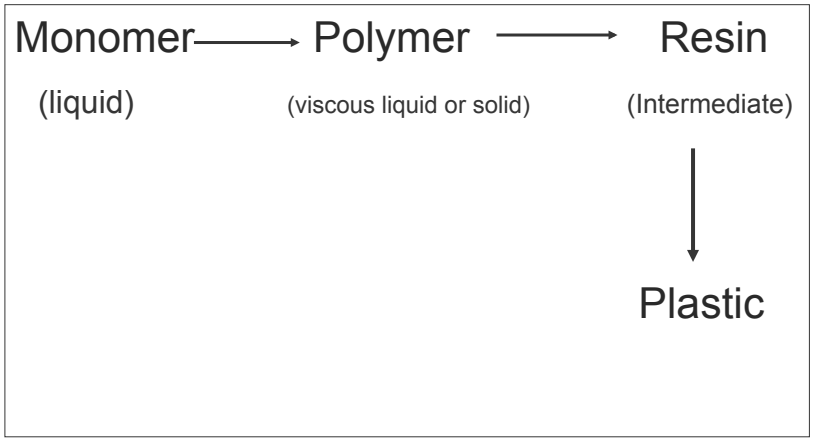
European plastics demand by segment 2013



PROCESSING

- PLASTIC
- FIBER
- ELASTOMER

PLASTIC TECHNOLOGY



MONOMER VS POLYMER

POLYMER	MONOMER
A polymer is a macroscopic material built from a large number of repeating single units bound together.	A monomer is a single repeating unit that is covalently bound to form polymers.
Polymers are complex molecules with very high molecular weight.	Monomers are simple molecules with low molecular weights.
A polymer will always have a single repeating unit.	A monomer can have different combination units.
Polymers are macroscopic molecules which are stronger than monomers and are less susceptive towards chemicals.	Monomers are small molecules in the microscopic scale which cannot be compared to the macroscopic properties of polymers. And they are chemically more reactive than polymers.

Pediaa.com

PLASTICS

- The word **plastic** comes from the Greek PLASTIKOS, which means to form or mold.
- **Plastics** are materials composed of polymers that can be readily formed or molded into a useful shape.
- A **resin** is a polymer that has not yet been formed into its final useful shape.

RESIN

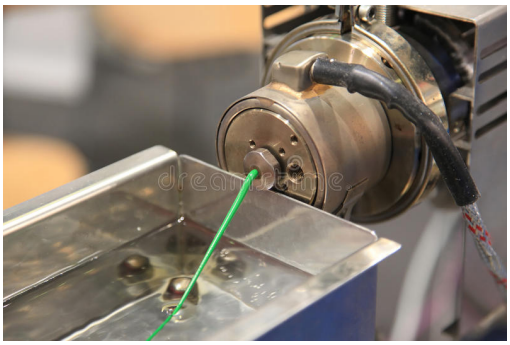
- Intermediate
- World resin producers

  DuPont, ICI, Exxon, Mobil, Hoechst, Shell, BASF, Allied Signal.

  Widely produced resins

  PE, PP, PS, PVC, PC, Nylon, PU, Polyesters.

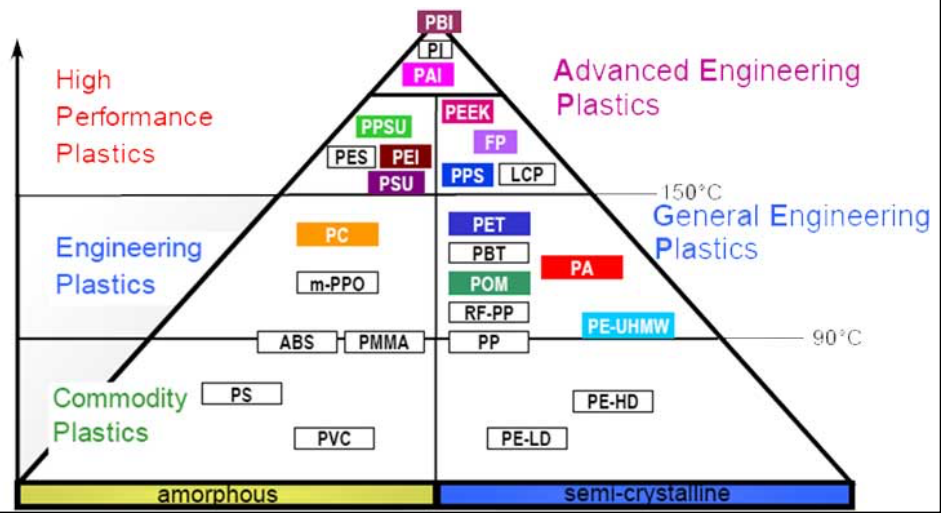
PLASTIC TECHNOLOGY



PLASTICS

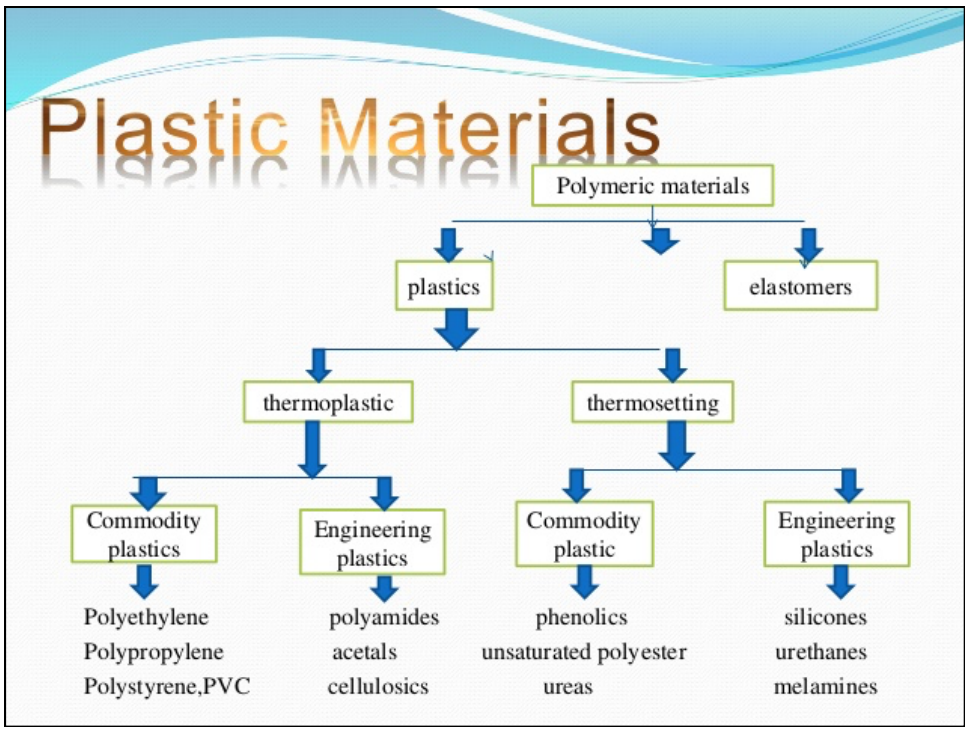
- Commodity Plastics
  PE, PE copolymers, PP, PVC, PS
- Engineering Plastics
  Polyamides, polyasetals, polycarbonates, polyacrylates, fluoropolymers

PLASTICS

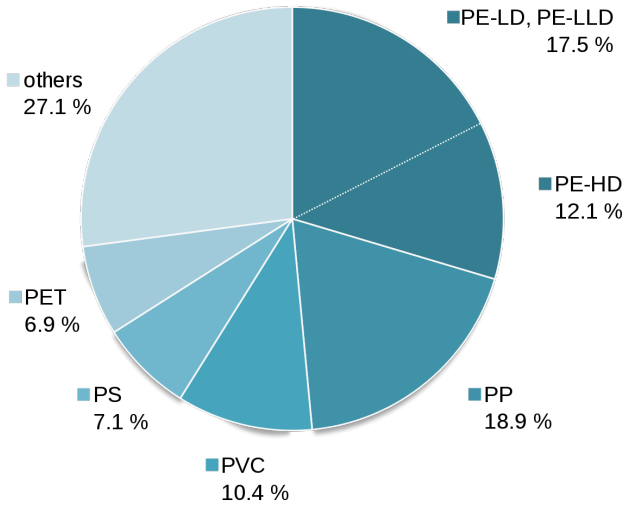


CONDUCTIVE POLYMERS

- Polyasetilene
- Polypyrol
- Polyaniline
- Polythiofene



PLASTICS



NATURAL FIBERS

- Silk
- Wool
- Cotton

SYNTHETIC FIBERS

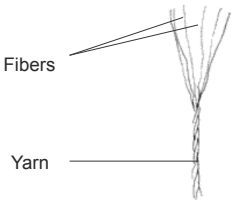
- RAYON (Modified cellulose)
- NYLON (Polyamide)
- ACRYLICS

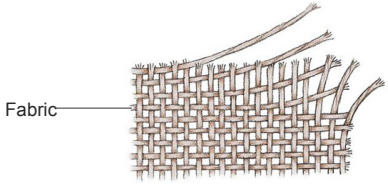
Processing

Fiber → Yarn → Fabric

Natural Fiber Source
or
Synthetic Polymer
Resin(Chip)

for various
applications



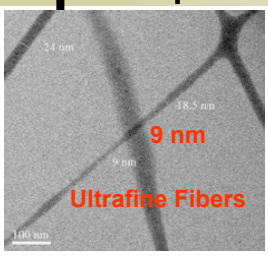


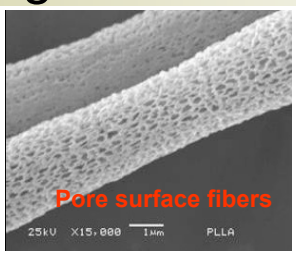
Synthetic Fiber Production

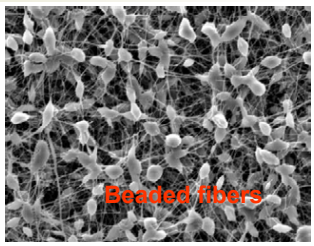
Initially, polymer chips are *melted* or *dissolved* in order to get them ready for spinning process.

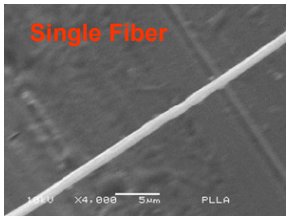
- Melt Spinning — After Extruded
- Wet Spinning — After Dissolving
- Dry Spinning — After Dissolving

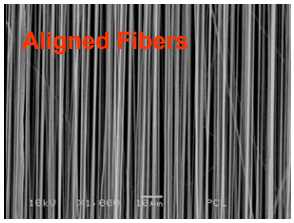
NANOFIBERS in different morphologies

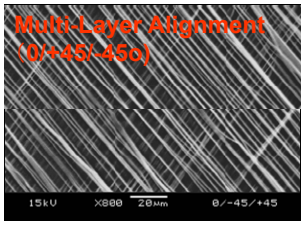










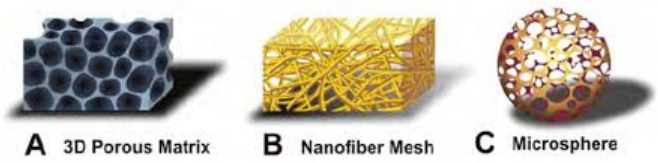


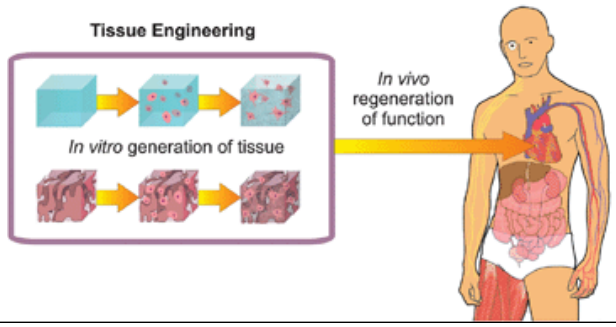
ELASTOMER TECHNOLOGY

- Elastomers are rubber-like materials.

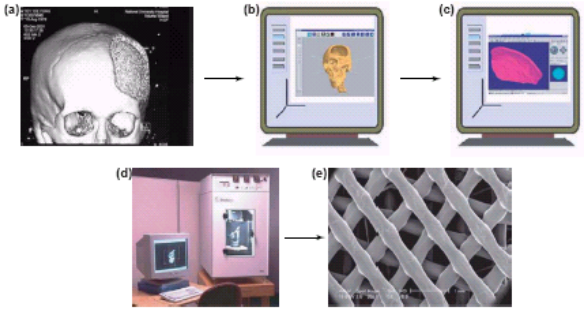
SBR
NBR
Silicon rubber
Butyl rubber

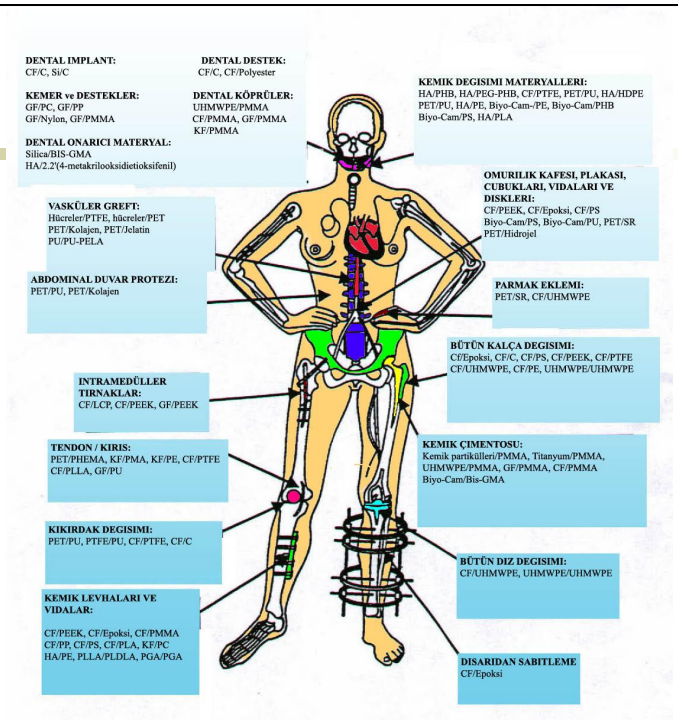
TISSUE ENGINEERING



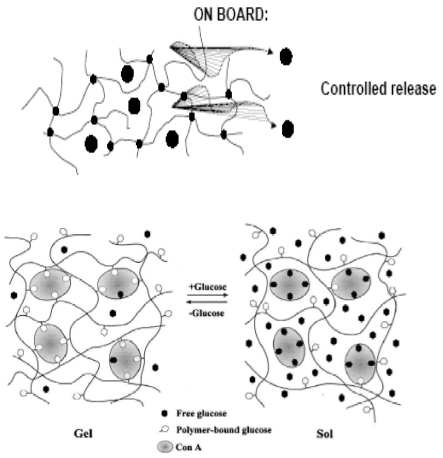


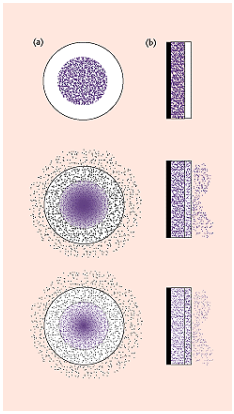
TISSUE ENGINEERING





CONTROLLED DRUG RELEASE





CLASSIFICATION OF POLYMERS

- Based on the Origin of the Polymer
  i) Natural polymers (ii) Semi-synthetic polymers (iii) Synthetic polymers
- Based on Structure of Polymers
  i) Linear polymers (ii) Branched chain polymers (iii) Cross linked polymers
- Based on Types of Monomers
  i) Homopolymer (ii) Copolymer (iii) Terpolymer
- Based on the Backbone of the Polymer
  i) Organic ii) Inorganic
  i) Homochain ii) Heterochain

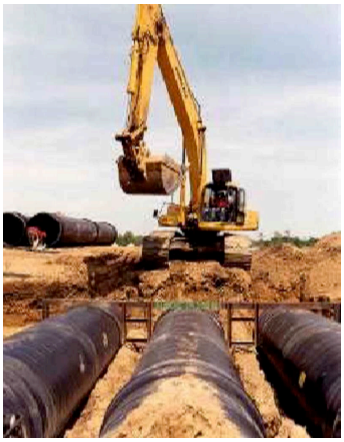
CLASSIFICATION OF POLYMERS

- Based on Thermal Processing Behaviour
  i) Thermoplastic Polymers (ii) Thermosetting Polymer
- Based on Tacticity (Configuration)
  i) Isotactic polymer (ii) Syndiotactic polymer (iii) Atactic polymer
- Based on Molecular Weight
  i) Oligomers ii) Intermediates iii)Macromolecules
- Based on Synthesis
  i) Addition polymers *(ii)* Condensation polymers

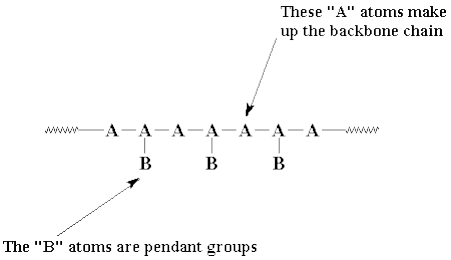
Based on the origin

- Natural polymers (Cellulose, starch, wool, cotton, chitin, etc.)
- Semi-synthetic polymers (Cellulose nitrate, cellophane)
- Synthetic polymers (Nylon, polyesters, polyethylene, etc.)

Synthetic Polymers

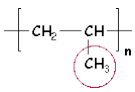


A **pendant group** on a polymer is a small group of atoms (even a small chain sometimes) that hangs off of the main chain (that is, the **backbone** of the polymer).

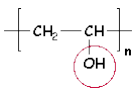


Here are some examples of pendant groups circled in red:

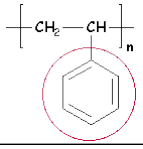
polypropylene

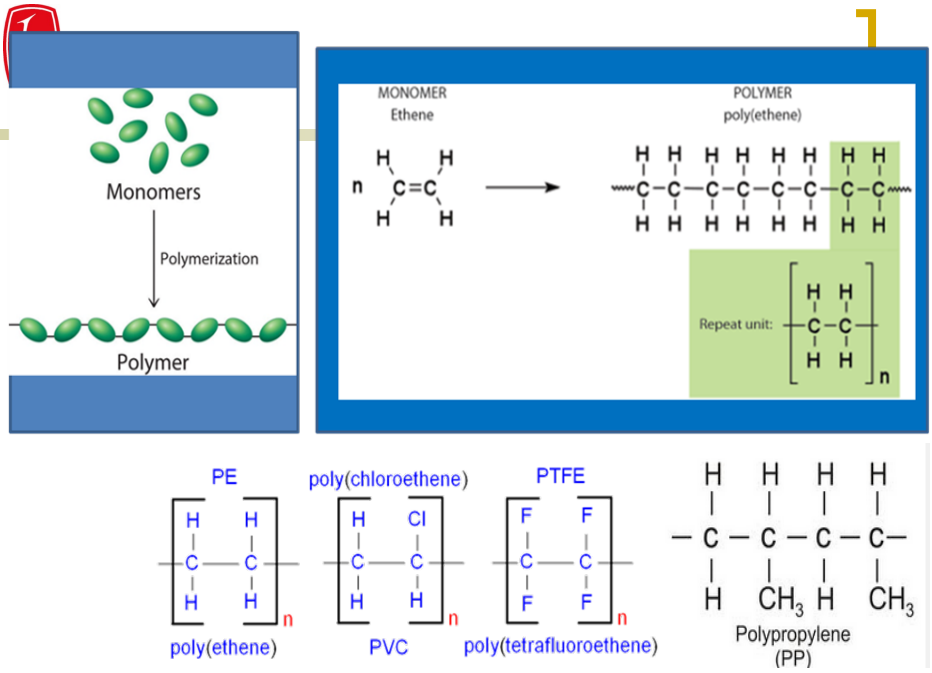


polyvinylalcohol



polystyrene



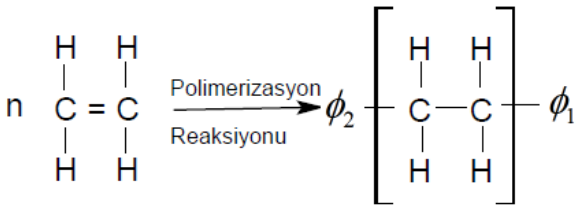


Natural Polymers

Based on the Synthesis

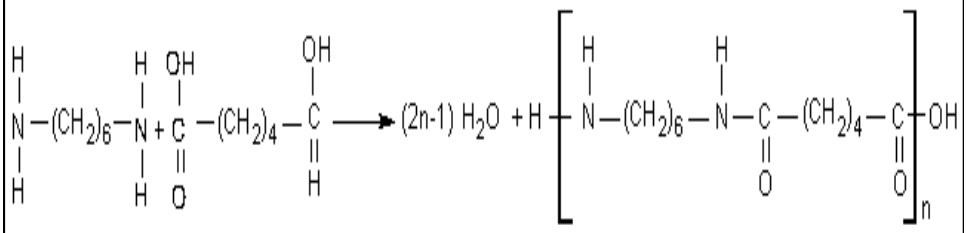
- Chain polymers (Addition polymers)
- Condensation polymers (step-growth polymers)

Chain Polymerization

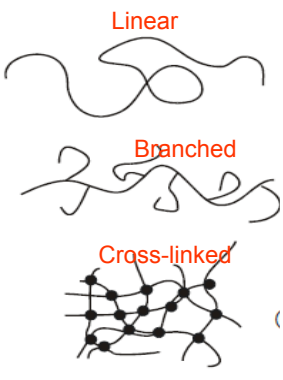


Etilen (monomer) Polietilen (PE)

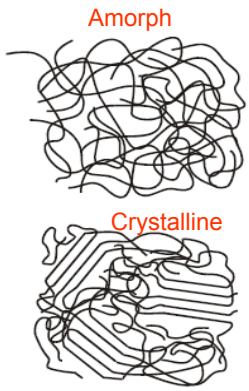
Condensation Polymerization



Besed on the Structure

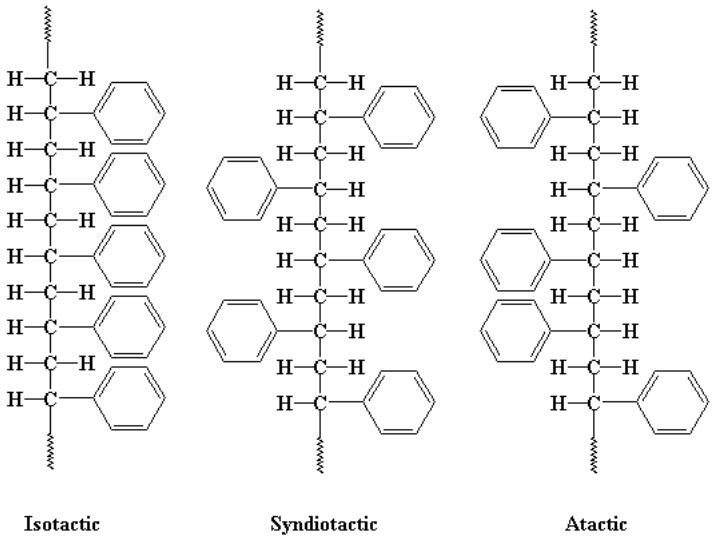


According to chain structure



According to solid structure

Based on Tacticity



POLYMER SCIENCE

- 1920 Herman Staudinger, “Macromolecule hypothesis”
  (1953 Nobel Award)
- 1937 Flory, mechanism of chain polymerization
  (1974 Nobel Award)
- 1950 Karl Ziegler-Cuha Natta, stereospecific catalysts
  (1963 Nobel Award)

POLYMER TECHNOLOGY

- Before 1800 ; natural polymers
- 1839; Goodyear, vulcanization of natural rubber
- 1868;Celluloid
- 1909; Baekeland phenolic resin.
  First technological product.
- 1925-1940;Synthesis of chain polymers.
  PVC, PMMA, PS, PE, PP, PAN, PVAc.

POLYMER TECHNOLOGY

- 1934; Carothers, Nylon and other condensation polymers
- 1955-1970; Silicon polymers, polyurethane etc.
- 1955-1970;Composites
- 1970-1990;Novel techniques in synthesis and processing
- 1990-2000;Sophisticated polymers:conductive polymers, degradable polymers.

Polymer Science and Technology I

- Introduction to Polymer Science: Definition; Classification; Historical Development; Uses; Prices; Raw Materials
- Polymer Structure; Binding; Configuration and Conformation; Molecular Weight.
- Polymer Synthesis: Step-Growth Polymerization and its Kinetics, Chain-Growth Polymerization, Free-Radical Polymerization and Copolymerization Kinetics; Ionic Polymerization
- Polymerization Techniques: Bulk; Solution; Suspension; Emulsion; Solid-state; Gas-phase and Plasma polymerizations.
- Special Topics in Polymer Synthesis; ATRP; Genetic Engineering, etc.

Polymer Science and Technology I

- Thermodynamics of Polymer Solutions; Phase Equilibria Predictions of Solubilities
- Measurement of Molecular Weight: Osmometry; Light Scattering Methods; Intrinsic Viscosity Measurements; GPC.
- Solid State Properties: Crystalline State; Crystallization Kinetics; Thermal Transitions and Properties;Mechanical Properties
- Polymer Degradation and Environment
- Introduction to Polymer Rheology
- Polymer Processing: General Remarks about Plastic, Fiber and Elastomer Technologies.

Polymer Science and Technology II

- Molecular Weight and Determination
- Introduction to Polymer Processing and Rheology
- Plastic Technology
- Fiber Technology
- Polymer Additives, Blends, Composites and Elastomers
- Polymer Degradation and Stability
- Management of Plastics in the Environment (Recycling, incineration, biodegradation)
- Hydrogels (Structural properties and synthesis, Applications)
- Bulk Characterization of Polymers (FTIR, ATR-FTIR, NMR, mechanical analysis, DSC, TGA and applications)
- Surface Characterization of Polymers (ESCA, SEM, AFM, and other techniques)
- Recent Advances in Polymerization Processes
- Polymers for Advanced Technologies (Polymeric membranes and separation processes, Biomedical applications, Electronic applications)

Polymer Science and Technology III

- Introduction to Polymer Technology
- Introduction to Polymer Processing Techniques
- Polymer Melt Flow
- Extrusion
- Injection Moulding
- Mould Design
- Other Processing Techniques
- Mechanical Behaviour of Plastics
- Recent Developments in Polymer Technology