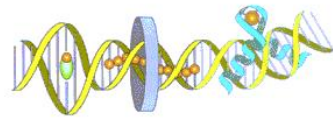




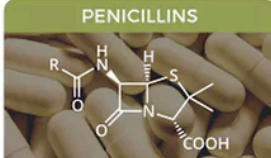
POLYMER SCIENCE and TECHNOLOGY I

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.

PENICILLINS



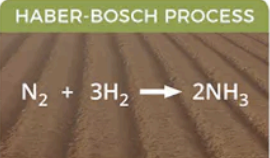
Alexander Fleming discovered penicillin in 1928, but it wasn't until 1939 that Howard Florey worked out how to make it in useful quantities. They were amongst the first drugs effective against multiple bacterial infections.

5

CHEMISTRY INVENTIONS that ENABLED THE MODERN WORLD

To coincide with the Royal Society of Chemistry's look at what people really think of chemistry, **Dr Mark Lorch** gives his top 5 chemistry inventions that make the world you live in possible. View the RSC's study here: <http://rsc.li/pac>

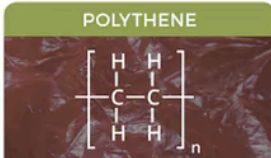
HABER-BOSCH PROCESS



$$\text{N}_2 + 3\text{H}_2 \rightarrow 2\text{NH}_3$$

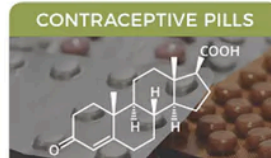
Plants need nitrogen, but a major limiting factor in agriculture is its availability. German chemists Fritz Haber & Carl Bosch worked out a way of combining hydrogen and nitrogen to make ammonia, which can be used as crop fertiliser.

POLYTHENE



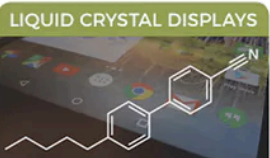
A large number of plastic objects you come across are made of some form of polythene. It was initially discovered in 1908, but a practical method for producing it wasn't developed until 1933. 80 million tonnes are made each year.

CONTRACEPTIVE PILLS



Russel Marker, an organic chemist, discovered a chemical in Mexican yams could be turned into the hormone progesterone in a single step. This made its production affordable, and led to the development of the first contraceptive pills.

LIQUID CRYSTAL DISPLAYS



Chemists have known about liquid crystals for some time, but room temperature LCD displays only became possible after George Gray's discovery of 5CB in 1972. 5CB derivatives are still present in TV, phone and laptop screens.

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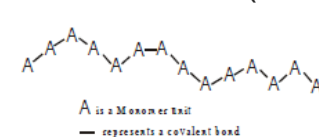
6

[


DEFINITIONS

]

- **POLYMER**
 POLY+MEROS (in Greek)



A is a Monomer Unit
— represents a covalent bond

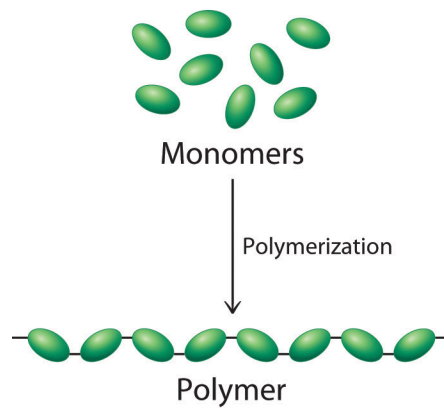


- The word polymer means many parts or units.
- Polymers are chain-like structures.
- A polymer is a molecule made up of smaller molecules that are joined together by chemical bonds, in general covalent bonds.



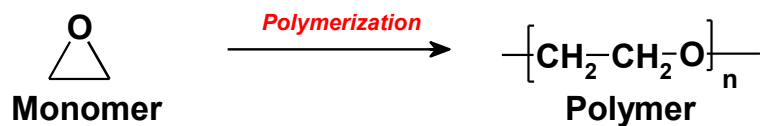
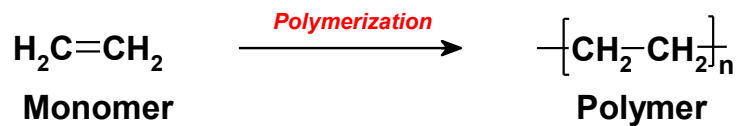
DEFINITIONS

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, flammability etc.

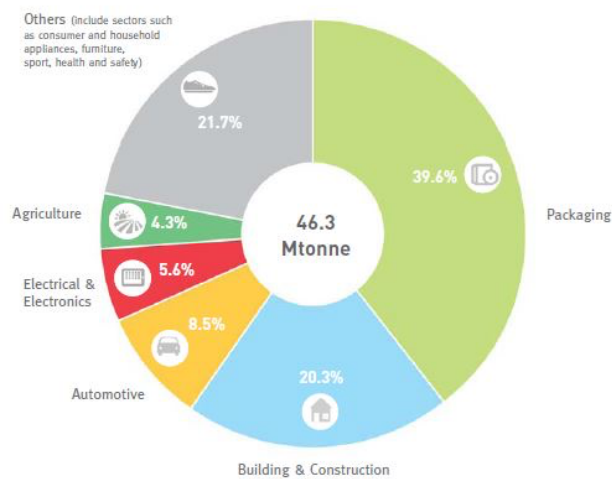


USES OF POLYMERS

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



European plastics demand by segment 2013



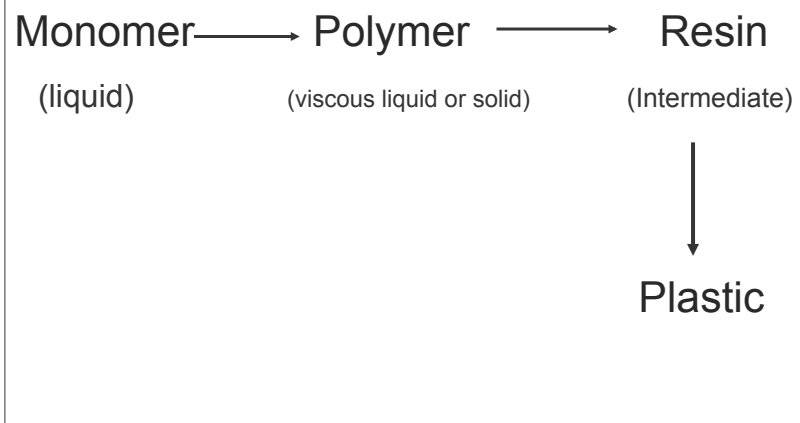



[PROCESSING]

- PLASTIC
- FIBER
- ELASTOMER



[PLASTIC TECHNOLOGY]



 MONOMER VS POLYMER	<p>A polymer is a macroscopic material built from a large number of repeating single units bound together.</p>	<p>A monomer is a single repeating unit that is covalently bound to form polymers.</p>
	<p>Polymers are complex molecules with very high molecular weight.</p>	<p>Monomers are simple molecules with low molecular weights.</p>
	<p>A polymer will always have a single repeating unit.</p>	<p>A monomer can have different combination units.</p>
<p>Pediaa.com</p>	<p>Polymers are macroscopic molecules which are stronger than monomers and are less susceptible towards chemicals.</p>	<p>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.</p>

- ## **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

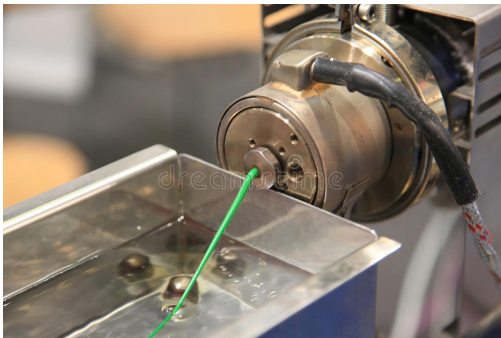
DuPont, ICI, Exxon,
Mobil, Hoechst, Shell,
BASF, Allied Signal.

Widely produced resins

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



[PLASTIC TECHNOLOGY]



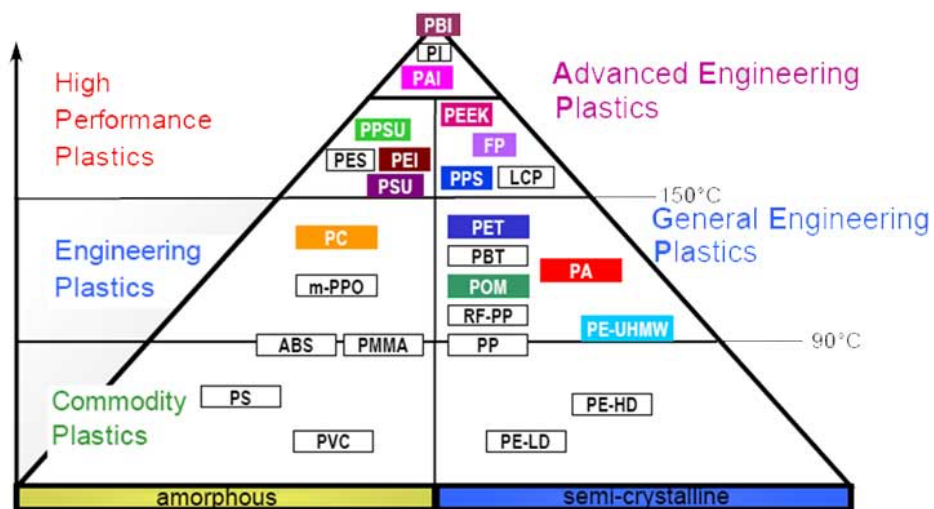


PLASTICS

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



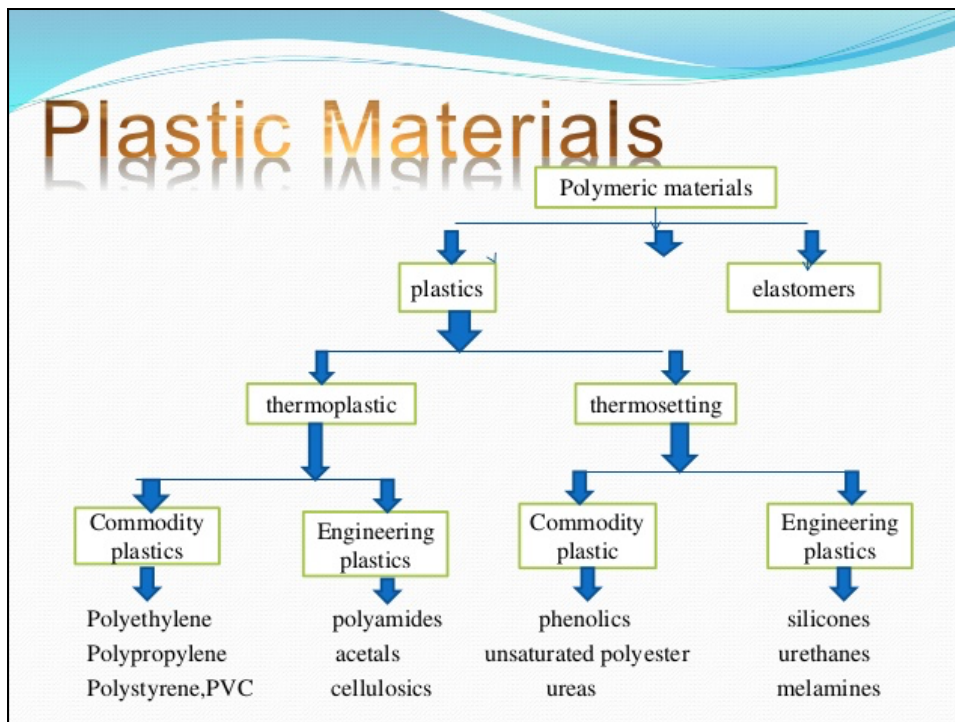
PLASTICS





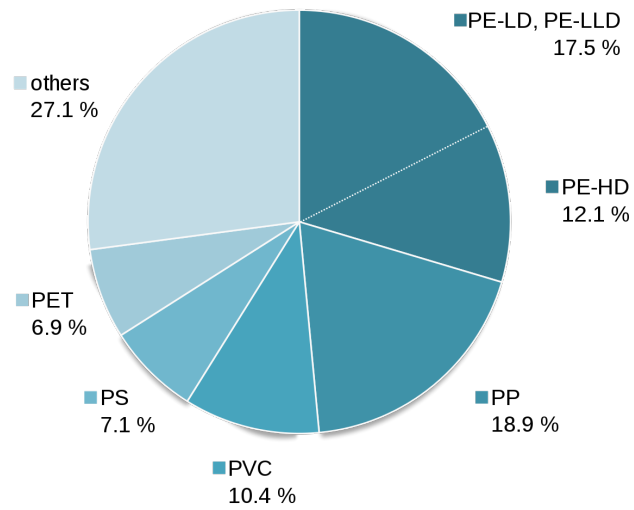
CONDUCTIVE POLYMERS

- Polyasetilene
- Polypyrol
- Polyaniline
- Polythiofene





[PLASTICS]



[NATURAL FIBERS]

- Silk
- Wool
- Cotton



[SYNTHETIC FIBERS]

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



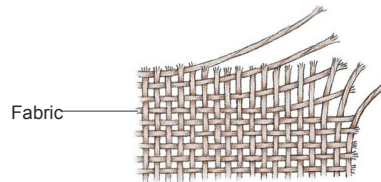
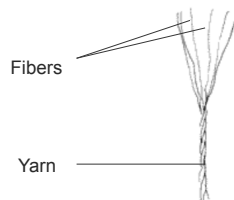
[Processing]



Natural Fiber Source
or
Synthetic Polymer
Resin(Chip)



for various
applications





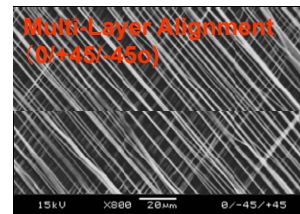
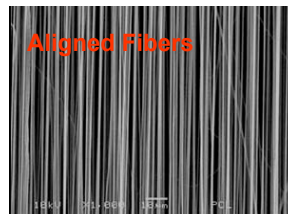
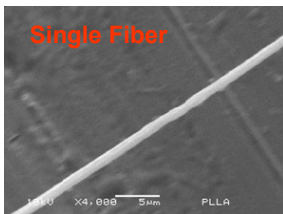
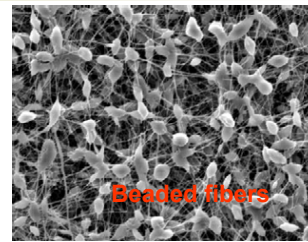
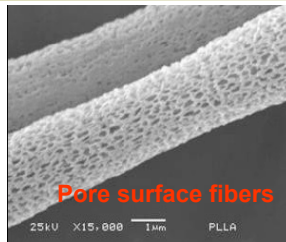
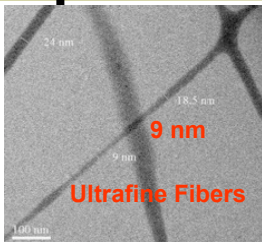
Synthetic Fiber Production

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

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



NANOFIBERS in different morphologies





ELASTOMER TECHNOLOGY

- Elastomers are rubber-like materials.

SBR

NBR

Silicon rubber

Butyl rubber



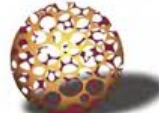
TISSUE ENGINEERING



A 3D Porous Matrix

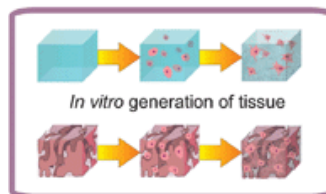


B Nanofiber Mesh

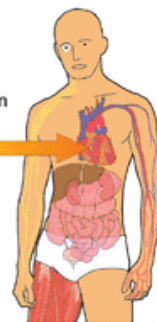


C Microsphere

Tissue Engineering

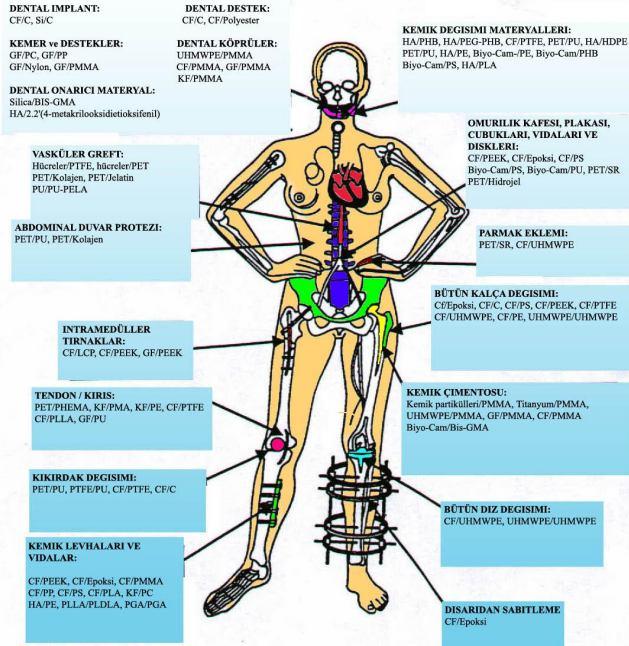
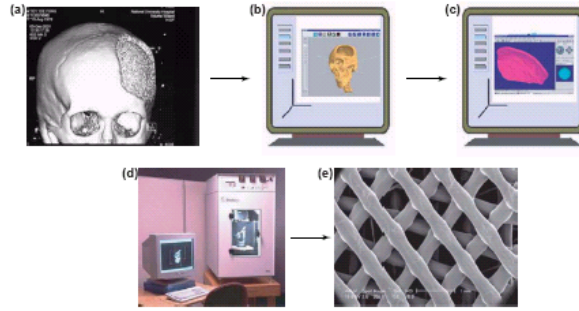


In vivo
regeneration
of function



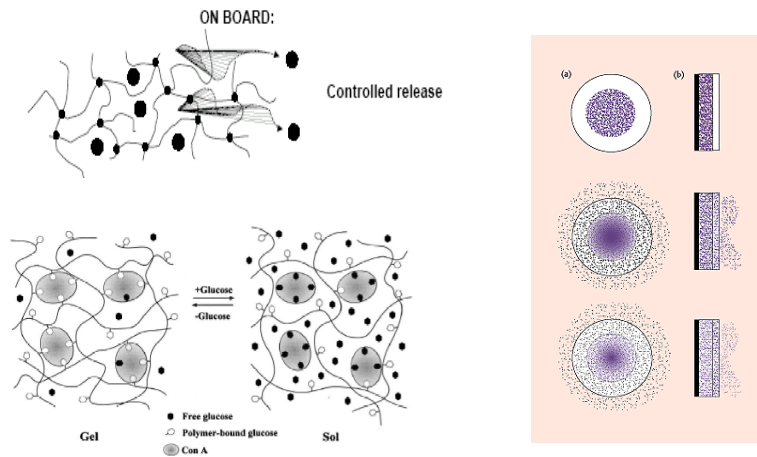


TISSUE ENGINEERING





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.)

6

Synthetic Polymers



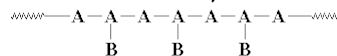
6



CHAIN
PENDANT

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).

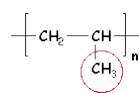
These "A" atoms make up the backbone chain



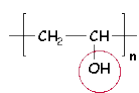
The "B" atoms are pendant groups

Here are some examples of pendant groups circled in red:

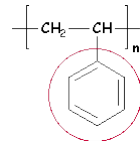
polypropylene

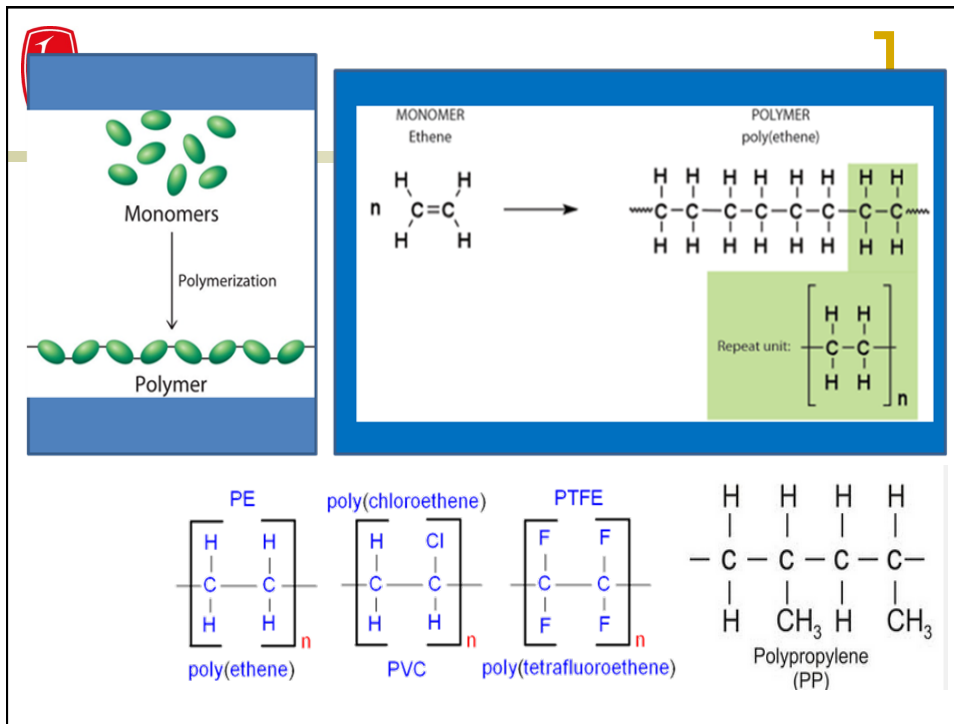


polyvinylalcohol



polystyrene





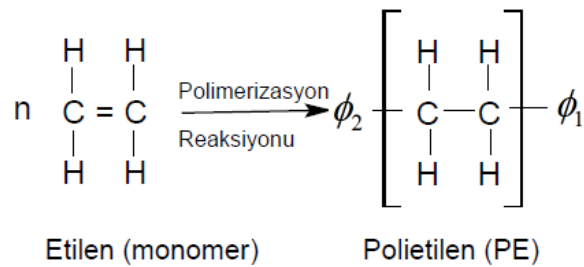


[Based on the Synthesis]

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

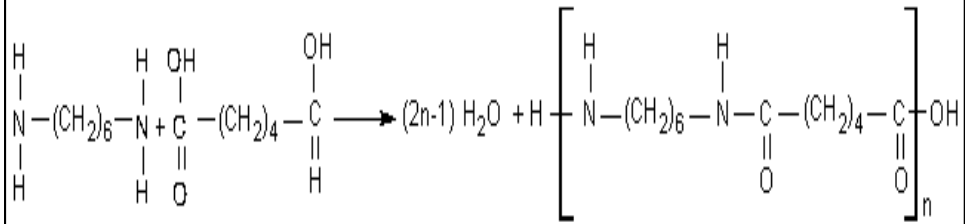


[Chain Polymerization]



6

Condensation Polymerization



6

Based on the Structure

Linear



Branched



Cross-linked



Amorph



Crystalline

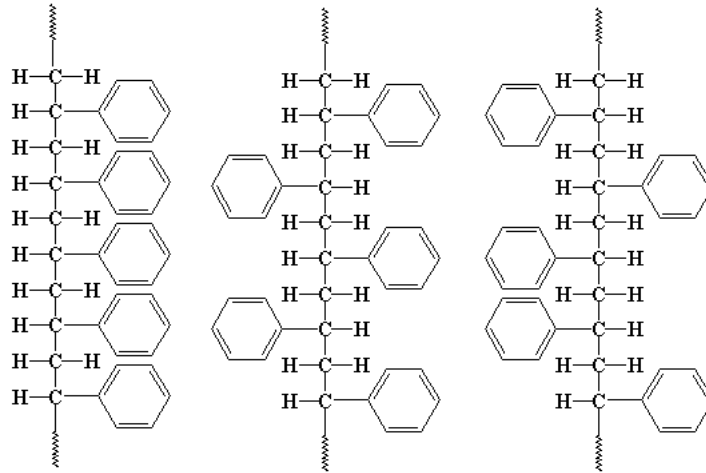


According to chain structure

According to solid structure

6

Based on Tacticity



Isotactic

Syndiotactic

Atactic

6

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