Magnetic Materials

Bar-magnet

Horseshoe magnet

Needle magnet

Cylindrical magnet

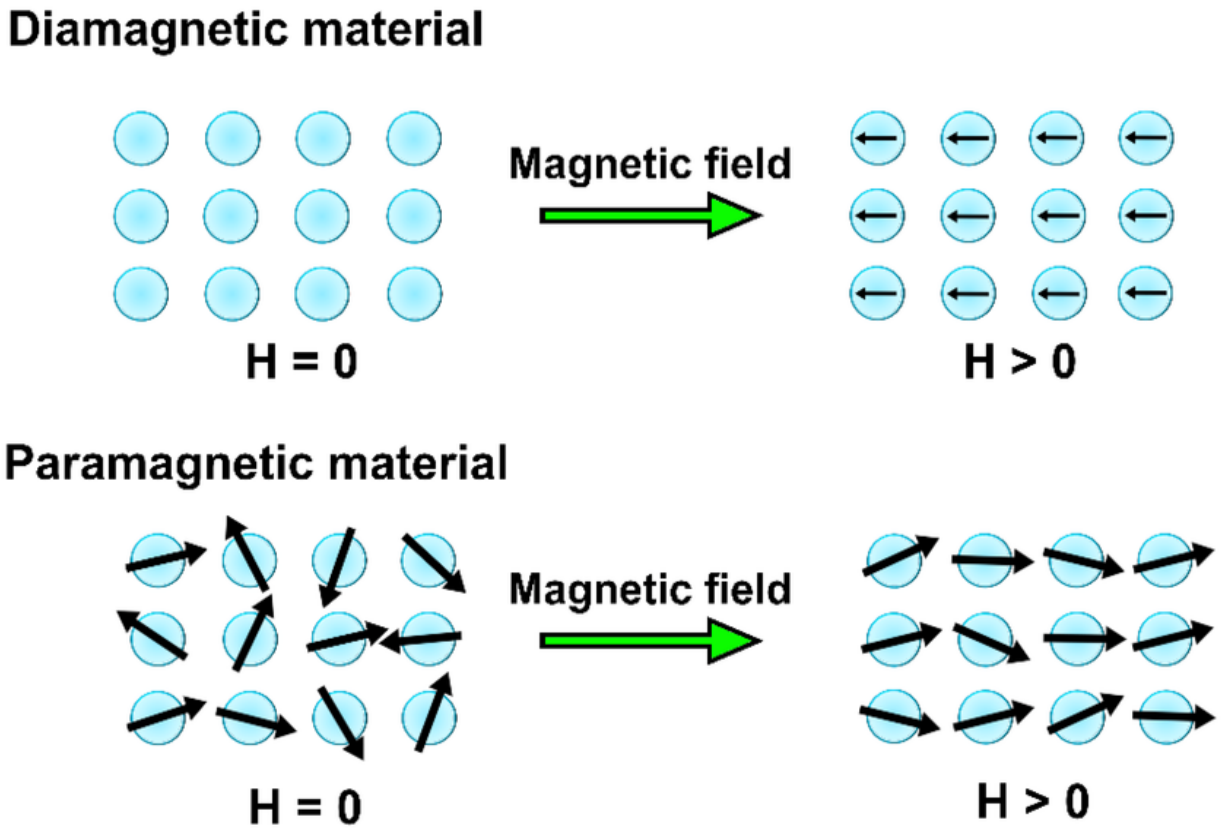
Oval shape magnet

Ring magnet

❖ **What is Magnetic Materials ?**

❑ Magnetic materials are substances that respond to an external magnetic field due to the presence and alignment of atomic magnetic moments, which mainly arise from unpaired electrons in partially filled d or f orbitals. Depending on how these moments interact, they can exhibit different behaviors such as diamagnetism, paramagnetism, ferromagnetism, ferrimagnetism, or antiferromagnetism. These materials are essential in applications ranging from permanent magnets and data storage to biomedical devices and spintronic technologies.

Classification of Magnetic Materials



In a magnetic field, H represents magnetic field intensity or magnetic field strength, and is measured in amperes per meter (A/m). It's a measure of the magnetizing force applied to a material, essentially quantifying how much a magnetic field can magnetize a material medium.

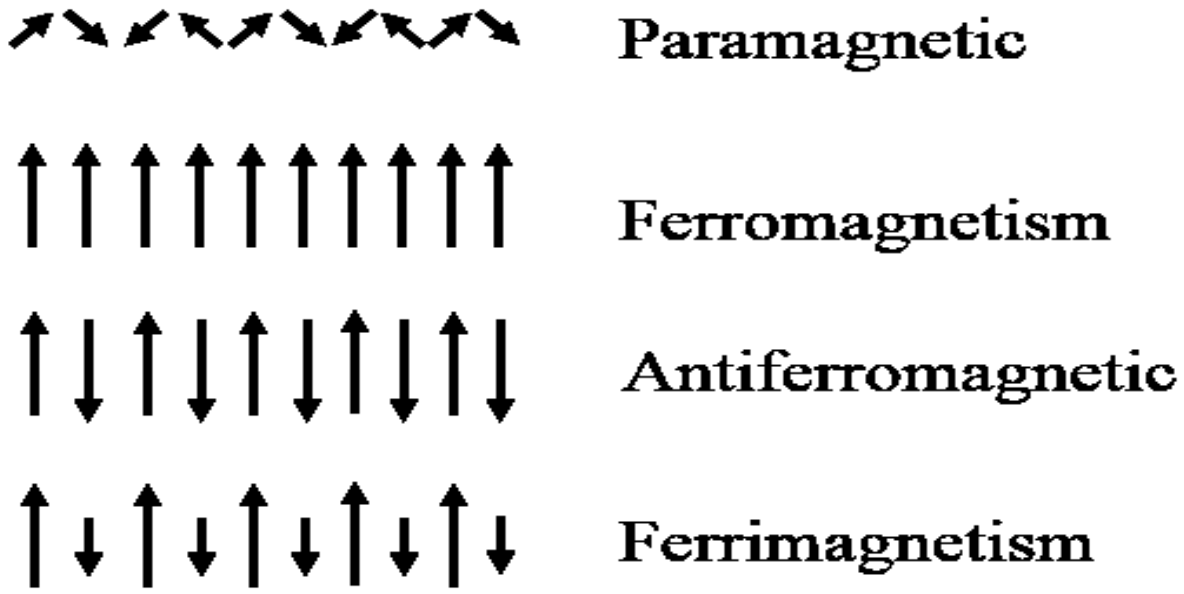
A. Diamagnetic Materials

- **Definition:** All electrons are paired; weakly repelled by an external magnetic field.
- **Magnetic Susceptibility (χ):** Small, negative.
- **Examples:** Cu, Ag, Au, Si, Bi.
- **Applications:** Magnetic levitation, MRI contrast agents (in some cases).

B. Paramagnetic Materials

- **Definition:** Have unpaired electrons; weakly attracted to a magnetic field; magnetization disappears when the field is removed.
- **χ:** Small, positive.
- **Examples:** Al, Pt, Cr^{3+} salts.
- **Applications:** Catalysts, magnetic probes in spectroscopy (EPR).

Classification of Magnetic Materials



C. Ferromagnetic Materials

- **Definition:** Strongly attracted to a magnetic field; possess spontaneous magnetization due to parallel alignment of atomic moments.
- **Key Property:** Magnetic domains.
- **Examples:** Fe, Co, Ni, and some alloys.
- **Applications:** Permanent magnets, magnetic storage, transformers.

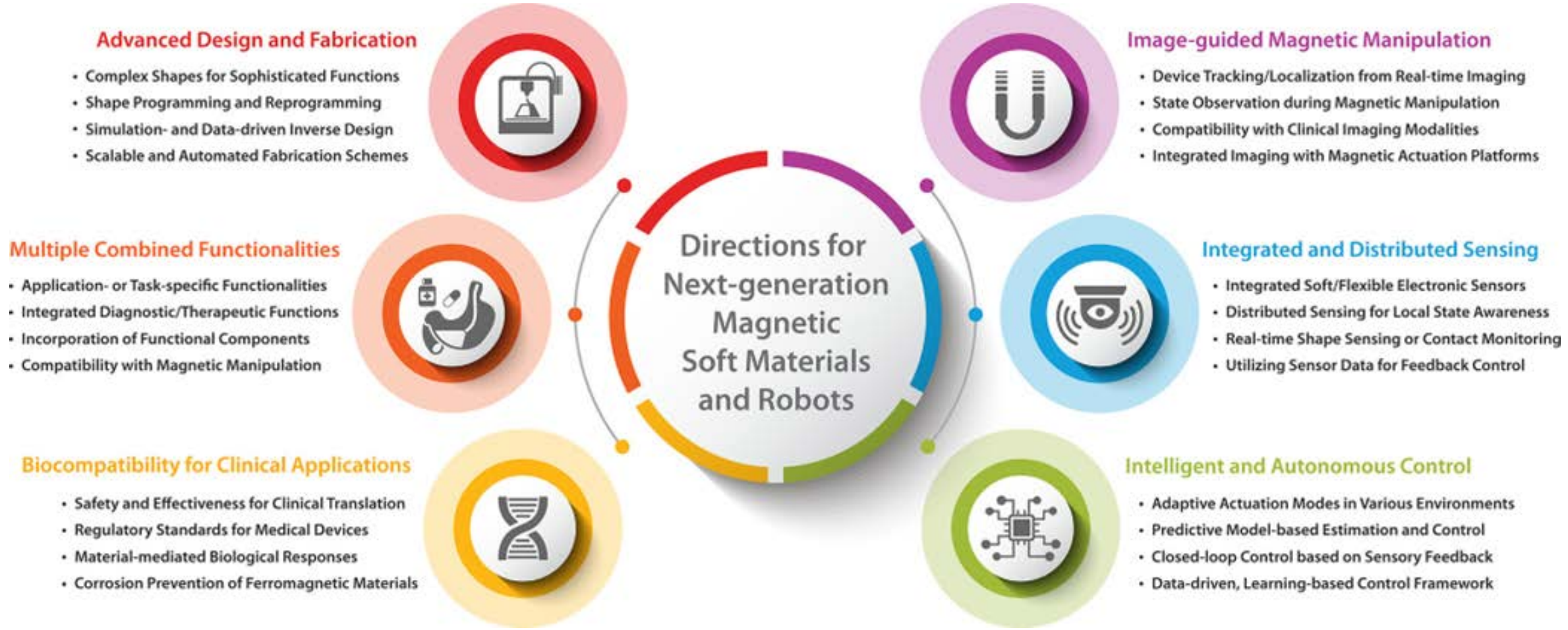
D. Ferrimagnetic Materials

- **Definition:** Magnetic moments of ions in different sublattices are antiparallel but unequal, resulting in net magnetization.
- **Examples:** Ferrites (Fe_3O_4, MFe_2O_4 with M = Mn, Co, Ni, Zn).
- **Applications:** Inductors, antennas, microwave devices.

E. Antiferromagnetic Materials

- **Definition:** Magnetic moments align antiparallel with equal magnitude, resulting in zero net magnetization.
- **Néel Temperature (T_n):** Transition point above which material becomes paramagnetic.
- **Examples:** MnO, FeO, NiO.
- **Applications:** Spin valves, magnetic sensors.

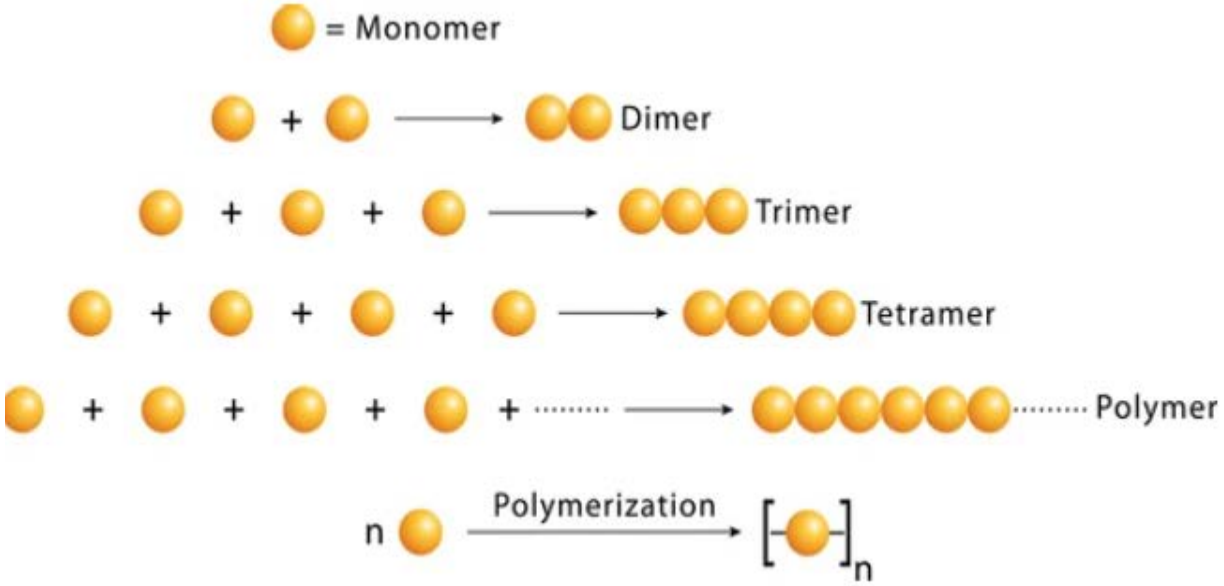
Application of Magnetic Materials



Chem. Rev. ***2022***, 122, 5, 5317–5364

Polymer

Topics to be discussed

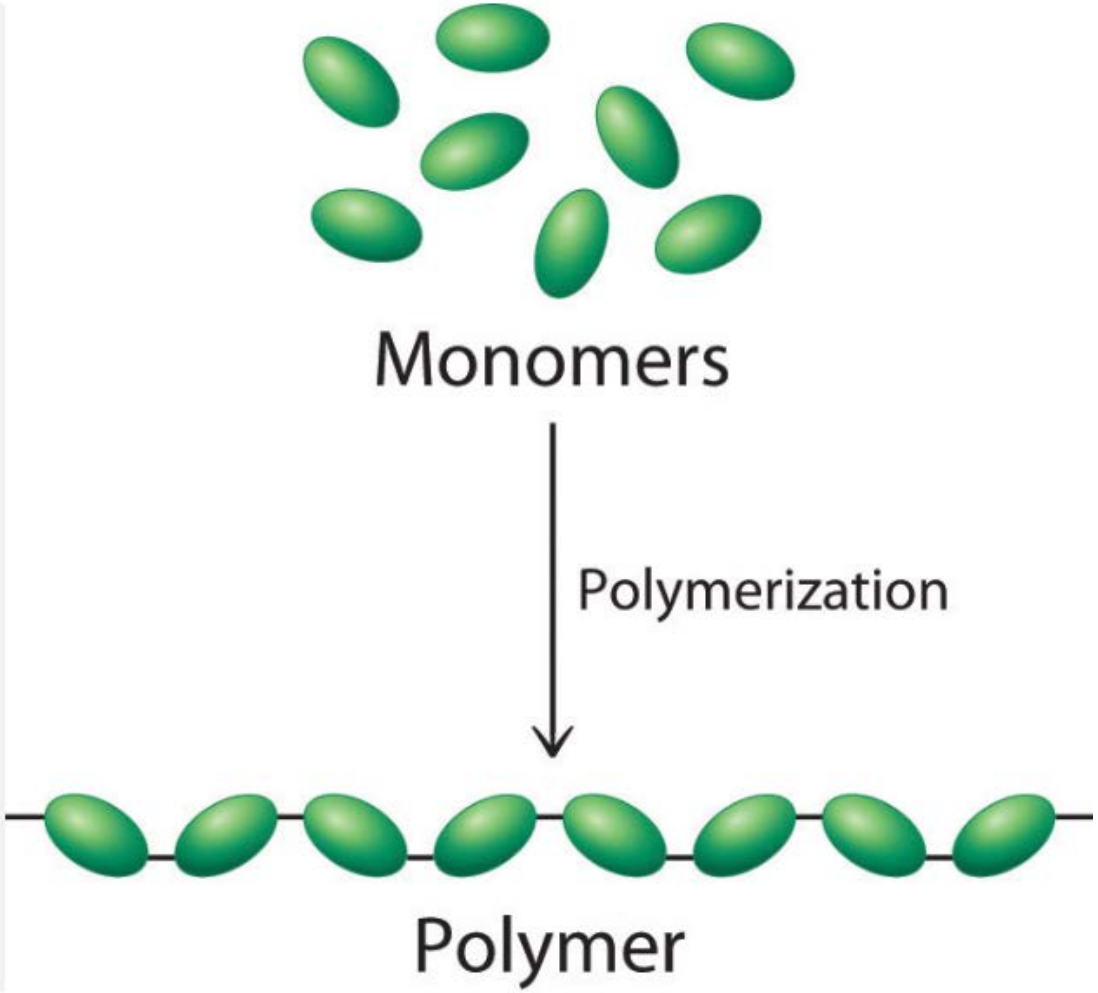


- ❑ Introduction to polymers
- ❑ Monomer and its functionalities
- ❑ Nomenclature of polymers
- ❑ Classification of polymers
- ❑ Short history of polymerization process

https://www.shutterstock.com/search/monomer?dd_referrer=https%3A%2F%2Fwww.google.com%2F

Introduction to Polymer

What is Polymer ?



- Polymers are macromolecules created by joining several tiny molecules known as monomers.
- The high molecular weight substance that results from a single repeating unit is known as a polymer.
- Large molecules with large molecular masses make up polymers.
- For instance, polyethylene is created when several ethylene molecules join as monomers.
- The starting point for creating a polymer is a monomer. "Polymerization" is the process of combining monomers to create a giant molecule.

What is Polymer ?

- Based on this physical characteristic, high polymers are defined as having a high degree of polymerization, whereas oligopolymers are defined as having a relatively low degree of polymerization.
- Degree of polymerization is the total number (n) of single monomer units that are joined together to form a polymer.

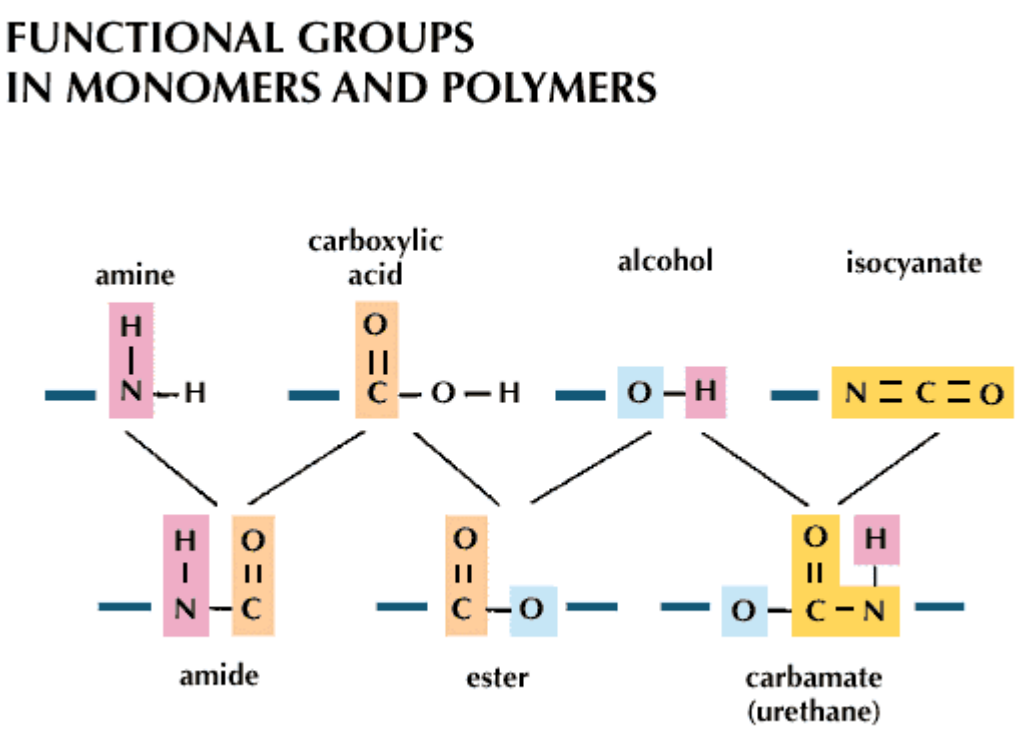
- **Definition of a Polymer:** A polymer is a large molecule formed by the repetition of small chemical units, arranged in linear, branched, or crosslinked structures, forming materials essential to modern life.
- **Emergence of Polymer Science**: Although vital, polymers were scientifically recognized only from the 1930s onward, with technological development accelerating later.
- **Industrial Importance:** Today, polymer-related industries employ over half of U.S. chemists and chemical engineers, underscoring their central role in science and industry.
- **Scope of Macromolecular Science:** It encompasses both biological polymers (key to life and nutrition) and nonbiological polymers, with this text focusing on the latter mainly synthetic materials like plastics, fibers, and elastomers.

https://www.bruker.com/en/applications/industrial/plastic-and-polymers/polymer-manufacturing.html

Fred W. Billmeyer, Text Book Polymer Science, Wiley

Polymer

❖ Functionality of a monomer



- A monomer's functionality is determined by the number of bonding sites it has with other monomers under the circumstances of the polymerization procedure.
- Thus, a bifunctional monomer is a monomer with functionality two, and can link to two other molecules under suitable conditions.
- A monomer that may interact with more than two molecules during polymerization events is said to be polyfunctional.
- Using vinyl monomers as an example, the double bond (CH_2 = CHX) can be thought of as a location for two free valencies.

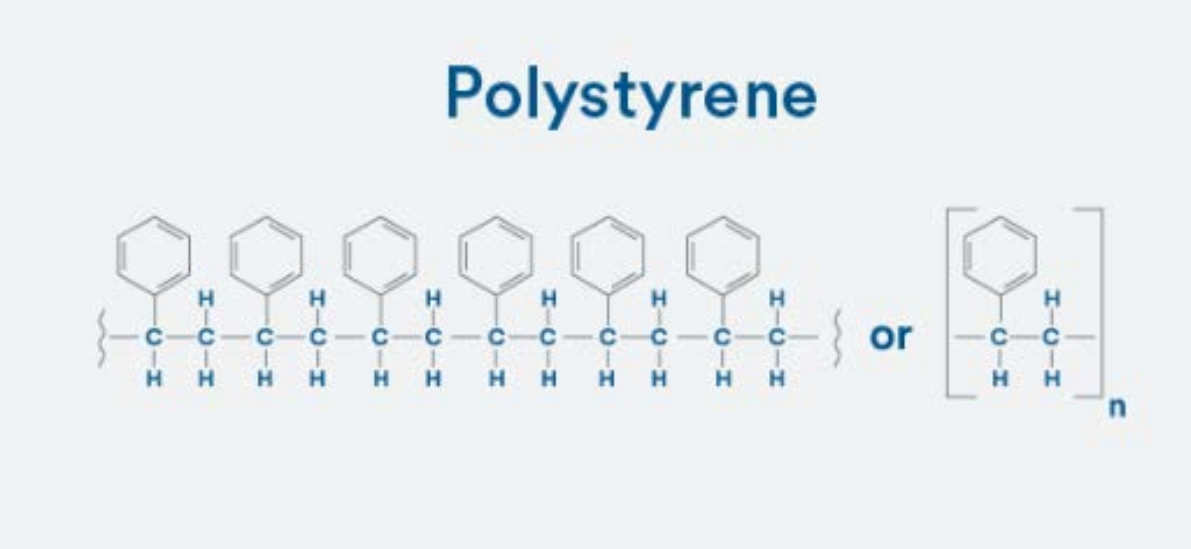
https://www.britannica.com/science/monomer

https://onlinecourses.nptel.ac.in/noc25_ch59/preview

Polymer

❖ Nomenclature of Polymers

❑ ***Polymers are classified into four types***



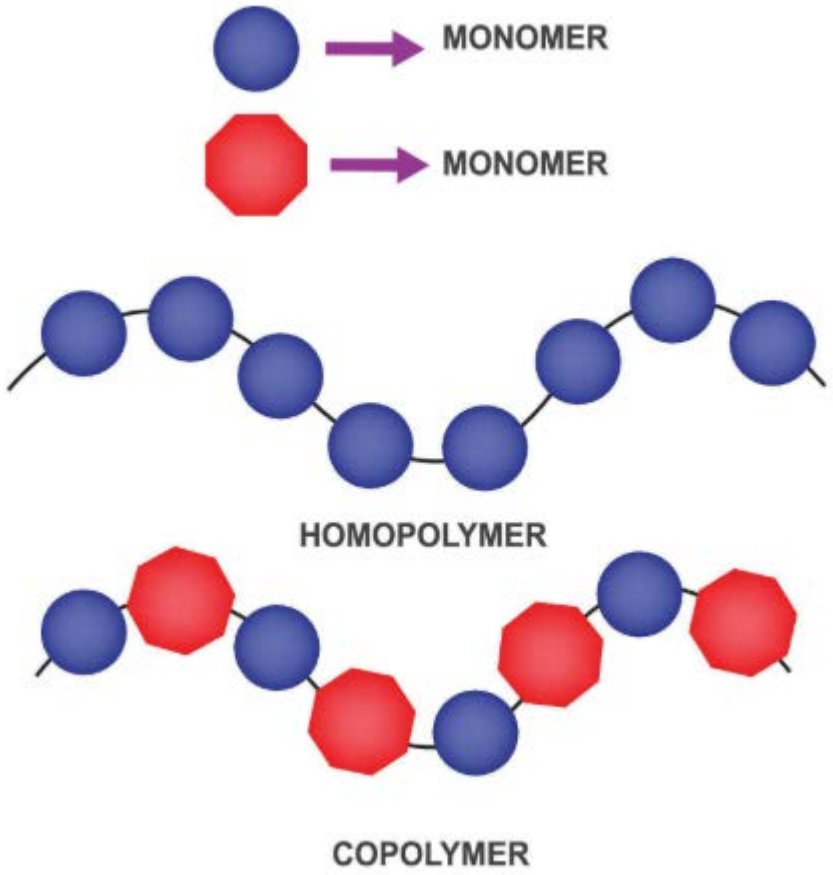
❑ Homo-Polymer

The polymer that is created from just one kind of monomer, or one kind of structural unit. The homo-polymers' characteristics are mainly specified by the monomer. At room temperature, polystyrene, for instance, is a rigid solid, whereas poly(butyl acrylate) is flexible and sticky.

❑ **Example:** Neoprene, PVC, polystyrene, polypropylene, polyethylene etc. are examples of the homo polymer.

Polymer

❖ Nomenclature of Polymers



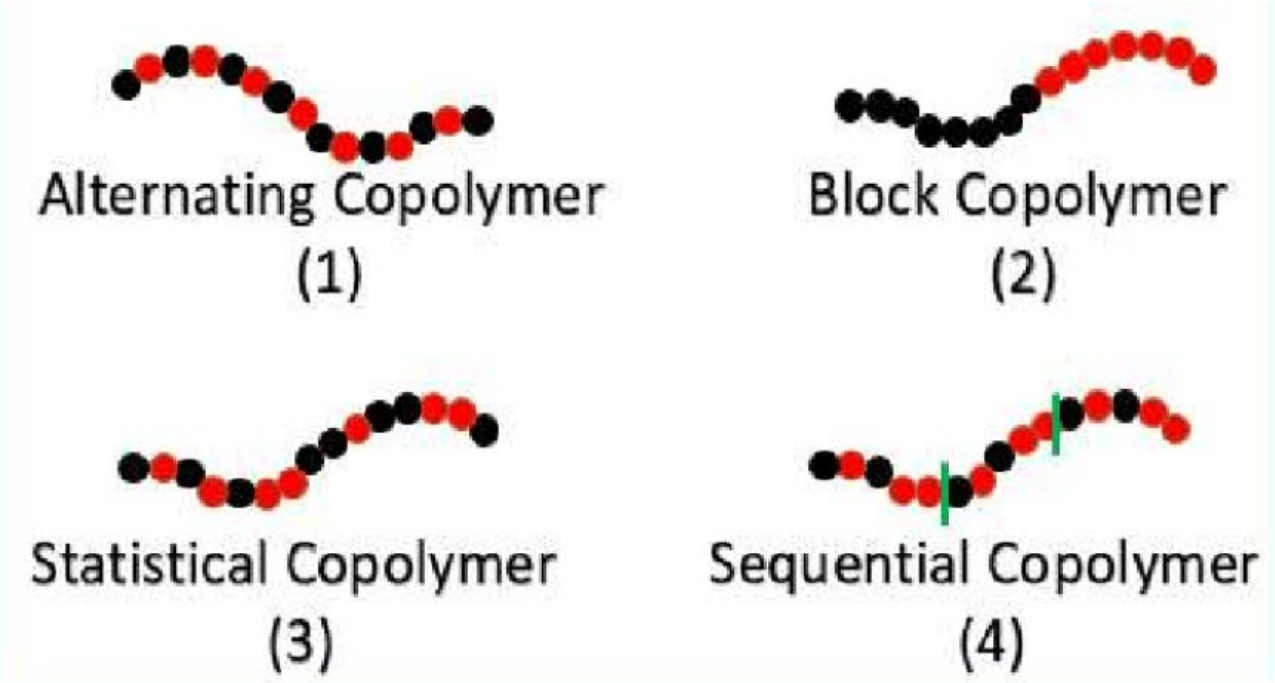
❑ Copolymers

- ❑ Copolymers are polymers made from two or more different types of monomers. Many of the commercially significant polymers are copolymers. In copolymers, the order in which the monomers are arranged is varied.
- ❑ The different types of monomers and their arrangements affect the copolymer's qualities. Two homo-polymers are joined to create a single polymer chain to create a block copolymer.
- ❑ There are several different types of copolymers, including statistical/random, alternative, block, gradient, and graft copolymers, based on the sequential distribution of the monomers.

https://www.vecteezy.com/vector-art/27798548-homopolymer-and-copolymer-vector-illustration

Polymer

❖ Nomenclature of Polymers

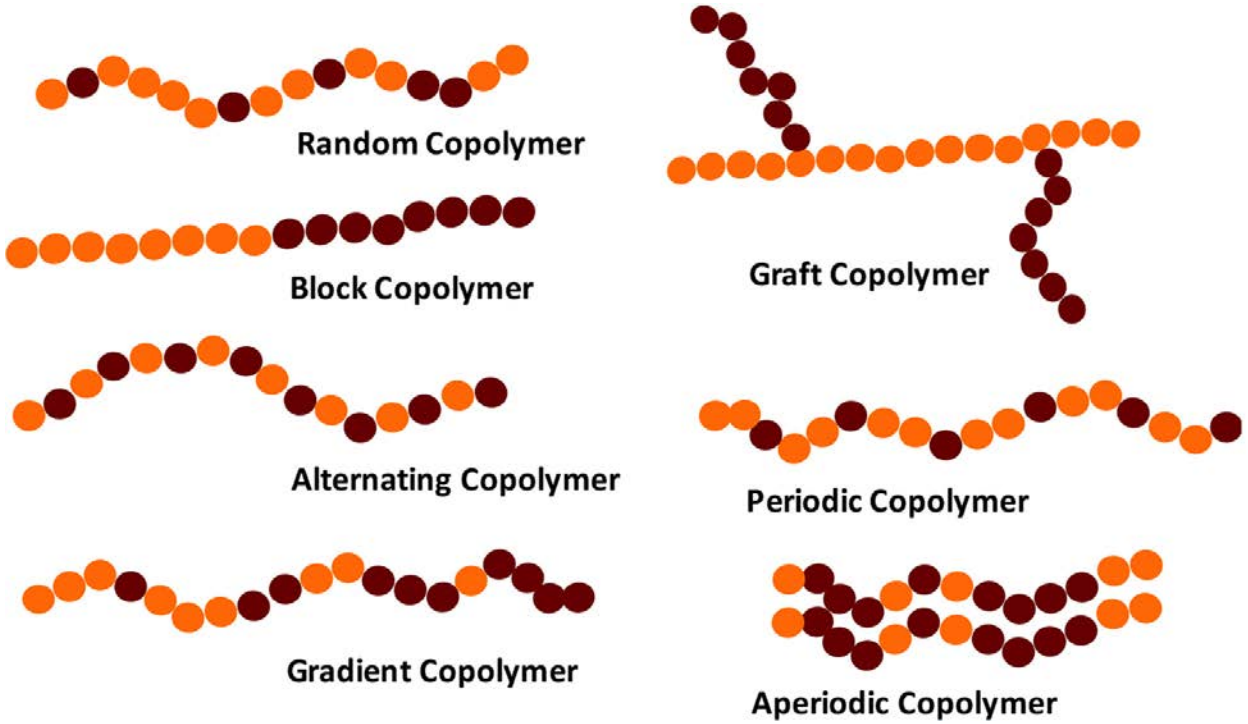


- **Statistical/random copolymer**
- The sequential distribution of monomers in these copolymers complies with the statistical law. Monomers are bonded at random in polymer chains to form random copolymers. The Markovian zero-order method is used to produce the random copolymer, since the nearby units do not affect the likelihood of finding a single monomeric unit at any given place in the chain.
- Random copolymer structure of polymer depends upon the random attachment of the monomers into the backbone of the polymers.
- **Example:**
  Poly(methyl methacrylate-stat-butylacrylate) is formed by random copolymerization of methyl methacrylate and butyl acrylate monomers by free radical polymerization process.

https://www.researchgate.net/figure/Most-common-copolymer-microstructures-alternating-copolymers-block-copolymers_fig2_331024941

Polymer

❖ Nomenclature of Polymers



❑ **Alternate co-polymers**

Alternating copolymers are copolymers in which two different monomers (A and B) alternate in a regular pattern along the polymer chain, i.e., ...–A–B–A–B–A–B–...

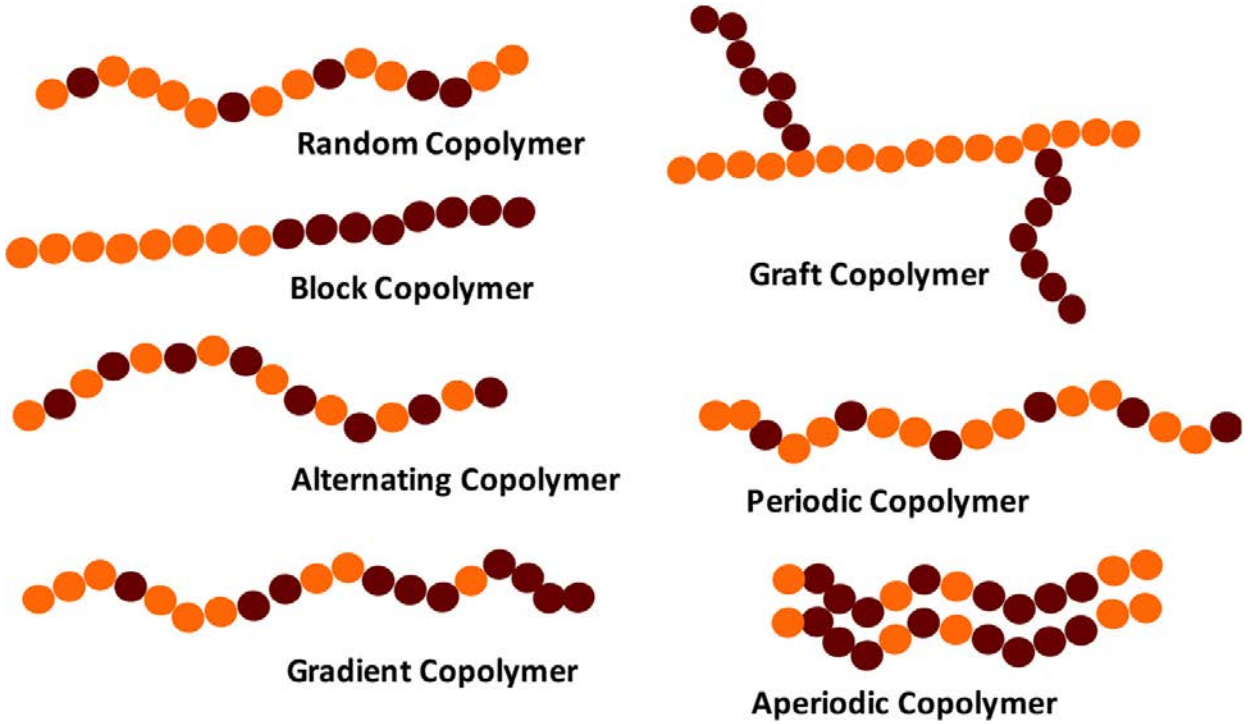
❑ **Key Importance of Alternating Copolymers:**

- ➢ Controlled and Uniform Structure
- ➢ Tailored Properties from Both Monomers
- ➢ Enhanced Compatibility and Stability
- ➢ Improved Mechanical and Thermal Performance
- ➢ Specific Functionality Design
- ➢ Electronic and Optical Applications
- ➢ Improved Barrier and Adhesion Properties

https://www.sciencedirect.com/science/article/pii/S0032386117300381

Polymer

❖ Nomenclature of Polymers



❑ Alternate co-polymers

A copolymer made up of two monomeric unit types dispersed in alternate series is known as an alternating copolymer.

- **Random copolymer**: Monomers arranged randomly
  Example: Styrene-butadiene rubber (SBR)
- **Alternating copolymer**: Monomers alternate regularly
  Example: Nylon-6,6
- **Block copolymer**: Blocks of one monomer followed by blocks of another
  Example: Styrene-butadiene-styrene (SBS)
- **Graft copolymer**: One type forms the main chain, another as side chains
  Example: Grafted polyethylene