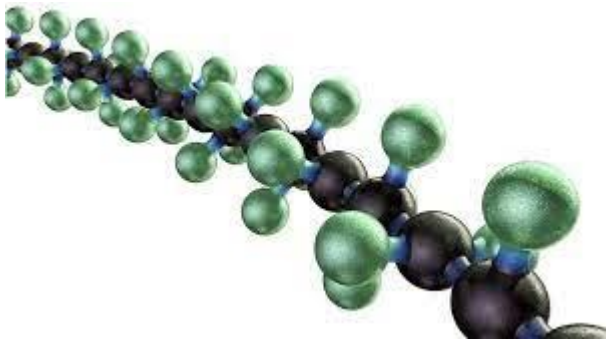
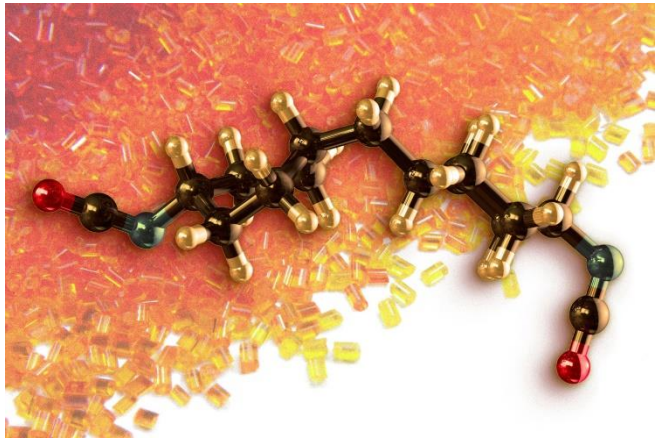
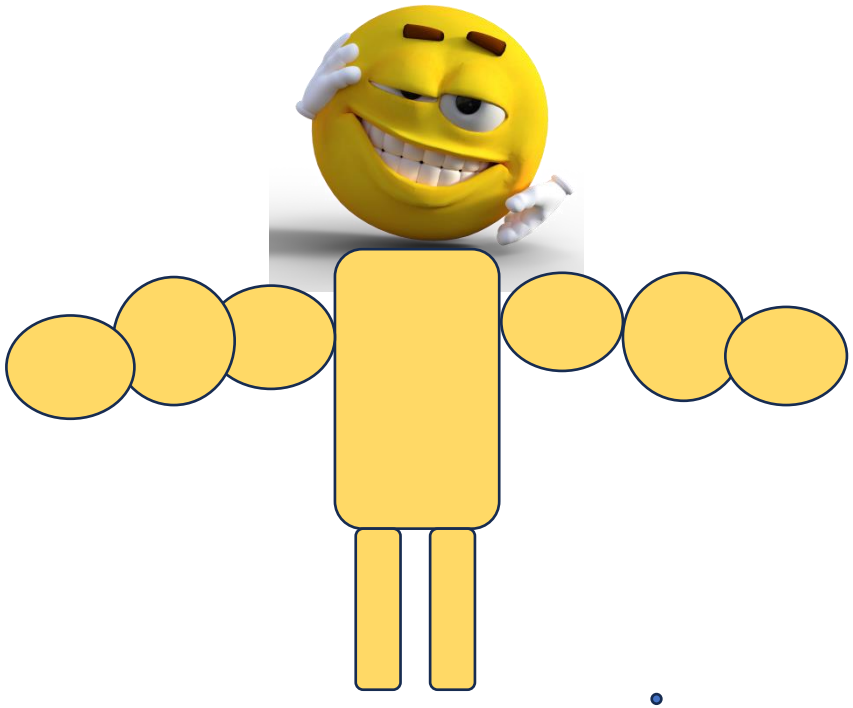
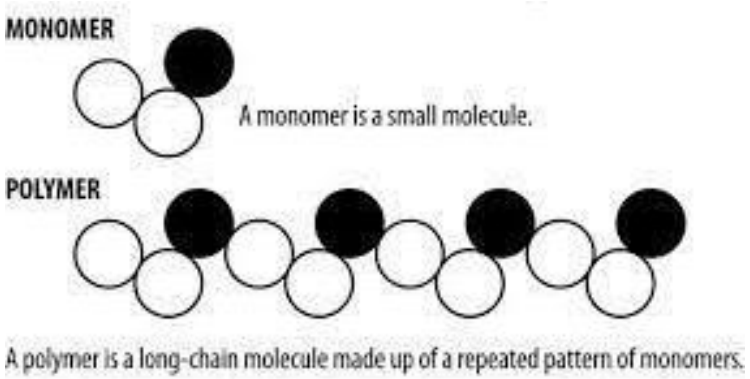


POLYMER





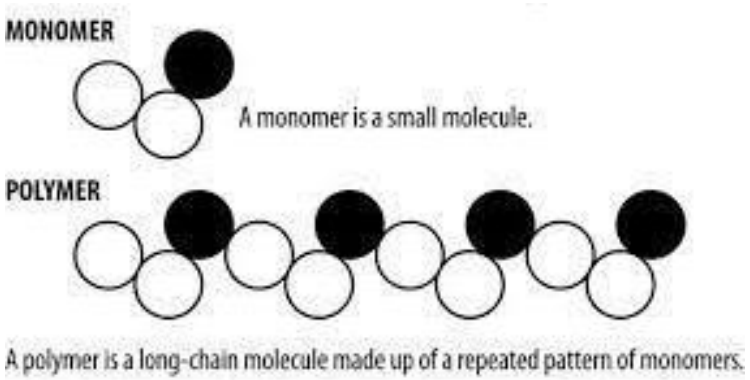


By Dr. Deepali N. Kanekar
Assistant Professor Chemistry

Q. What distinguishes polymers from other types of compounds?

ANS: THEIR extremely large size of the molecules. (Which measured as Molecular weight)

- Polymers have average molecular weights ranging from tens of thousands up to several million atomic mass units.
- It is to this vast molecular size that polymers owe their unique properties, and
- it is the reason that the German chemist Hermann Staudinger first referred to them in 1922 as macromolecules, or “giant molecules.”



What is the need to study polymer?

- Polymers can be found in a variety of natural and synthetic materials and play a crucial role in our everyday lives.
- Natural polymers (derived from biological sources) like proteins, nucleic acids like DNA and RNA.
- Synthetic polymers: used for numerous applications due to their versatility, durability, and customizable properties. Common synthetic polymers include polyethylene, polypropylene, polyvinyl chloride (PVC), polystyrene, and polyethylene terephthalate (PET). These polymers are used in various industries, including packaging, textiles, construction, automotive, electronics, and more.

How we can classify polymer?

Classification of Polymers

- **Nature of Repeat Units**
- **Structural Characteristics**
- **Stereochemistry**
- **Physical properties**
- **Molecular (Functional Group) Classification**
- **Polymerization Process**

- All highlight certain aspect or property of the polymer.

On the basis of Nature of Repeat Units

Homopolymer- A-A-A-A-A-A-A-A-A-A-A-A-

(identical repeat units)

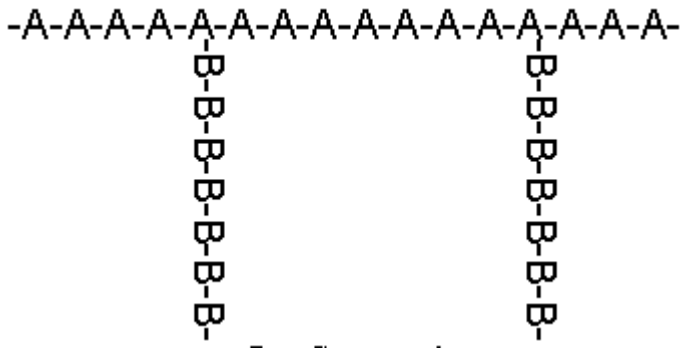
Copolymer - Different repeat units

Alternating Copolymer- A-B-A-B-A-B-A-B-A-B

Block Copolymer - AAAAAAAA-BBBBBBBBB

Random Copolymer- AA-B-A-B-B-A-A-A-B-B-A

Graft Copolymer-

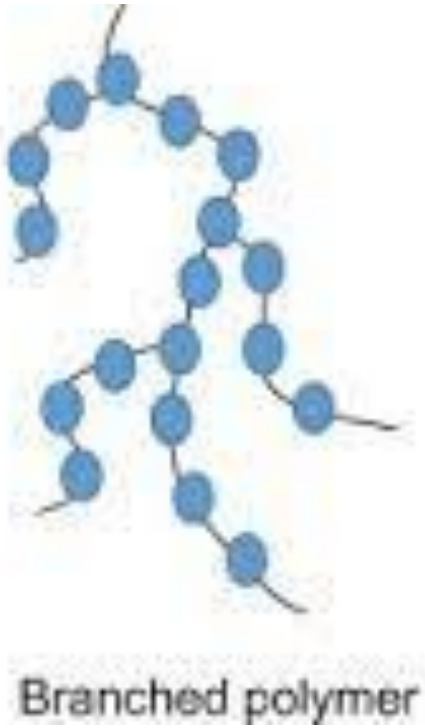


The structure of macromolecules

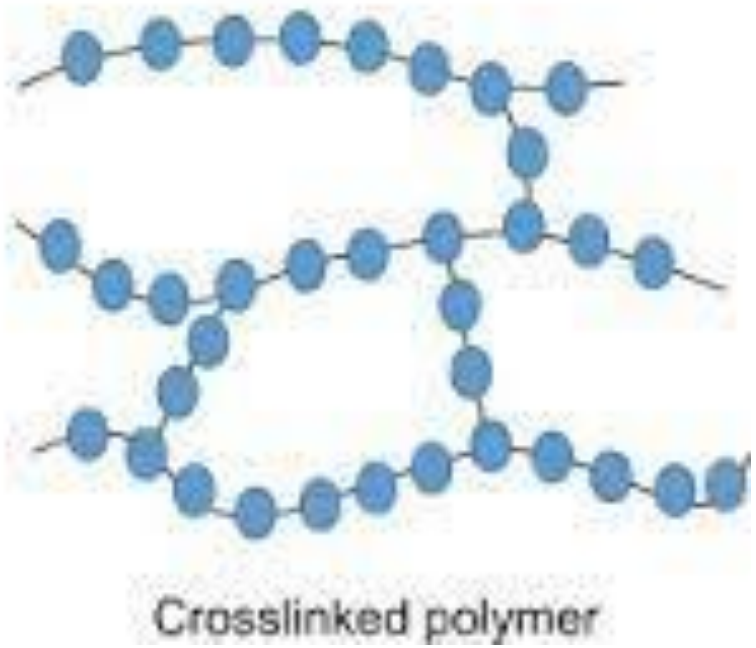
- **Linear, branched, and network**

Polymers are manufactured from low-molecular-weight compounds called monomers by polymerization reactions, in which large numbers of monomer molecules are linked together. Depending on the structure of the monomer or monomers and on the polymerization method employed, polymer molecules may exhibit a variety of architectures.

Linear polymer



Branched polymer

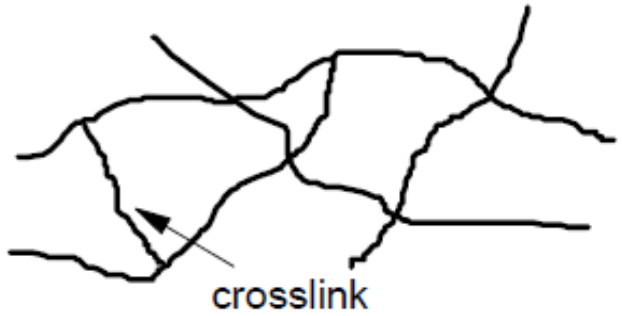


Crosslinked polymer

Structural characteristics-closely related to materials properties

linear (uninterrupted straight chain)

branched (occasional branches off longer chain)

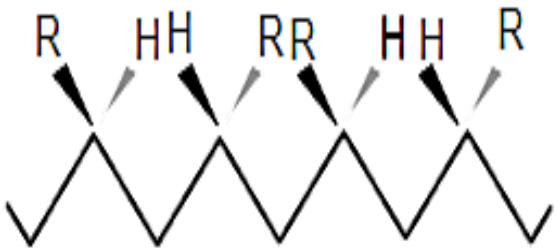


networked (many interconnected linear chains; one giant molecule)

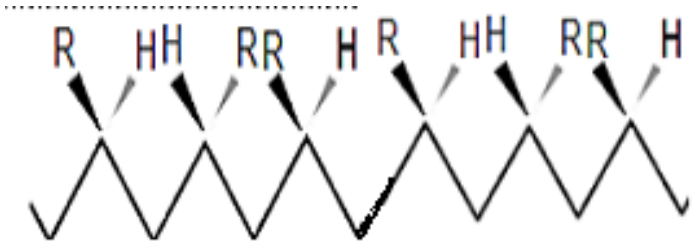
- Polymers can classified on the basis of <u>configuration</u> of macromolecule known as **tacticity**.

Stereochemistry of Linkages

ISOTACTIC – R groups on same side of backbone



SYNDIOTACTIC – R groups on alternating sides of backbone



ATACTIC — Random (most common)

Classification of Polymers : On the basis of Physical Properties

Amorphous Polymers: exhibit a random arrangement of polymer chains, transparent, low chemical resistance, have lower melting points, and are generally more flexible. Eg. polystyrene and amorphous polyethylene terephthalate (APET).

Semi-Crystalline Polymers: have regions of ordered, crystalline structure interspersed with amorphous regions. High melting points, greater stiffness, opaque and better dimensional stability eg. polyethylene (PE), polypropylene (PP), and polyamide (nylon).

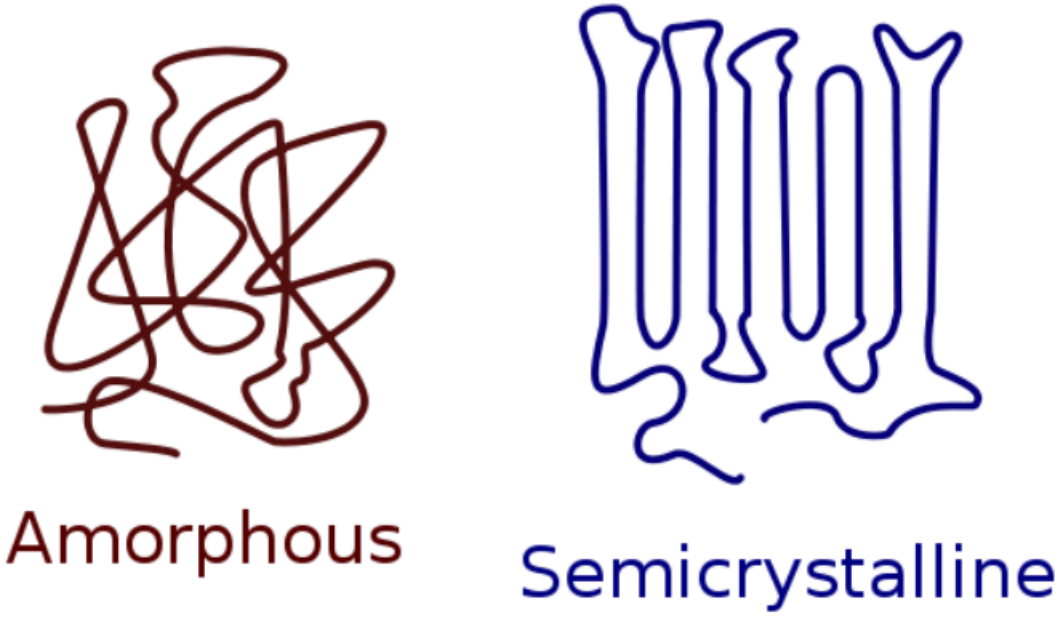


Figure 01: Molecular chains in amorphous and semicrystalline polymers

Elastomers: Elastomers are polymers that exhibit high elasticity and can return to their original shape after being stretched or deformed. They have a low modulus of elasticity and are characterized by their ability to undergo large deformations. Eg. styrene-butadiene rubber (SBR) and polyurethane.

Thermoplastics: Thermoplastic polymers can be melted and remoulded multiple times without undergoing significant degradation. They have a linear or branched polymer structure and can be processed using various techniques like injection moulding, extrusion, and blow moulding. Eg. polyethylene (PE), polypropylene (PP), and polyvinyl chloride (PVC).

Thermosetting Polymers: These polymers undergo a chemical cross-linking reaction during curing, resulting in a rigid and infusible network structure. Once thermosetting polymers are cured, they cannot be melted or remoulded. Eg. epoxy resins, phenolic resins, and melamine formaldehyde.

Conducting Polymers: have ability to conduct electricity. They possess a conjugated molecular structure that allows for the movement of charge carriers (electrons or holes). Conducting polymers find applications in electronics, sensors, and energy storage devices. Eg. polyaniline, polypyrrole, and poly(3,4-ethylenedioxythiophene) (PEDOT).

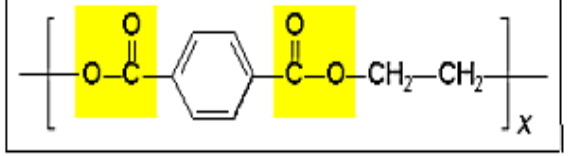
Barrier Polymers: Barrier polymers have low permeability to gases, liquids, or vapours, Used in packaging applications to prevent the transmission of oxygen, moisture, or other substances. Eg. polyethylene terephthalate (PET) and ethylene vinyl alcohol (EVOH).

Molecular (Functional Group) Classification

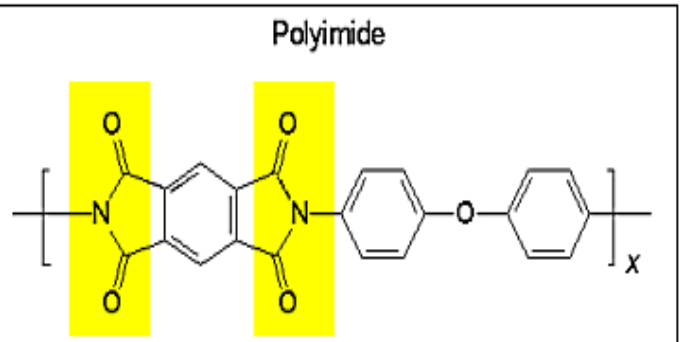
- Polymers are conveniently represented by the repeating chain formula, which shows the arrangement of bonds and atoms.
- The repeat units contain functional groups that describe the polymer.
- This terminology emphasizes the functional groups involved in the synthesis of the polymer from its monomers, although the usage is seldom exact.

Examples

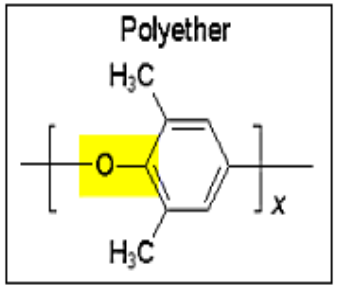
Polyester



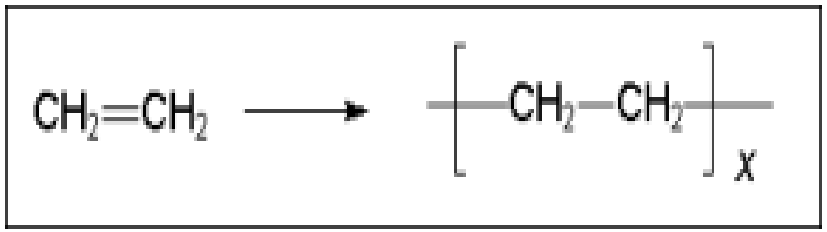
Polyimide

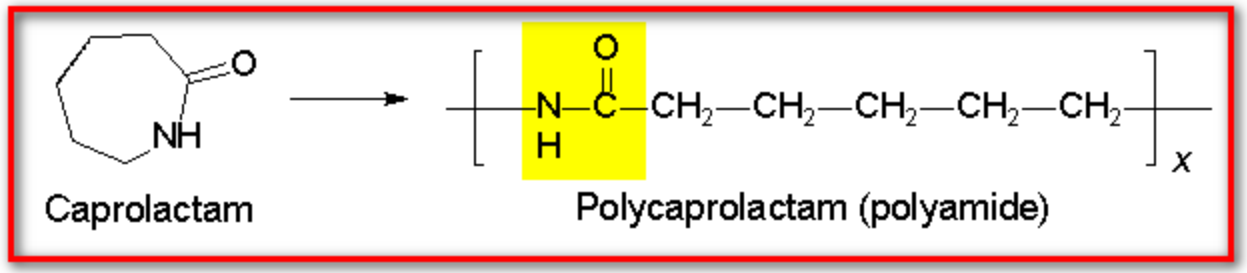


Polyether



A polymer is often named according to the monomer that was used to form it. This is why the polymer consisting of only a long chain of CH_2 groups is called *polyethylene*, not *polymethylene*.



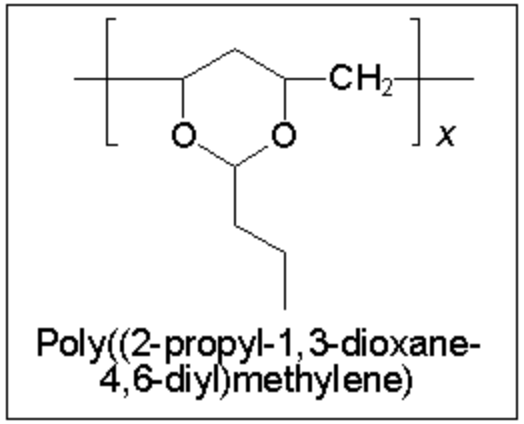


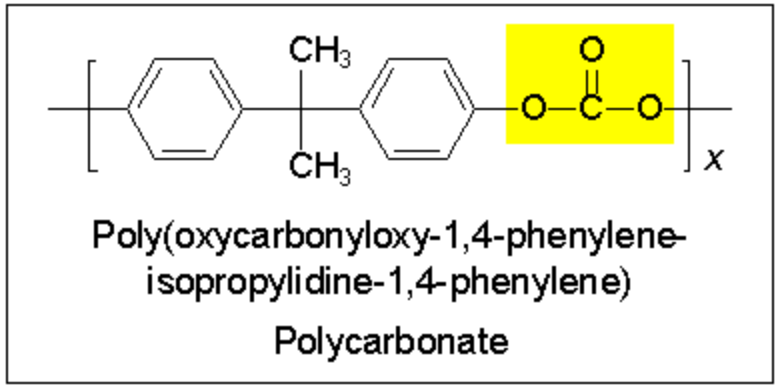
A polyamide containing 6 carbons is known as polycaprolactam.

Of course, there are systematic rules for polymer nomenclature set forth by the IUPAC, but for polymers with any complexity, the names are too cumbersome for common usage. IUPAC Polymer Nomenclature: see examples

•*Pure Appl. Chem.* **1976,** *48*, 373.

•*Macromolecules* **1973,** *6*, 149

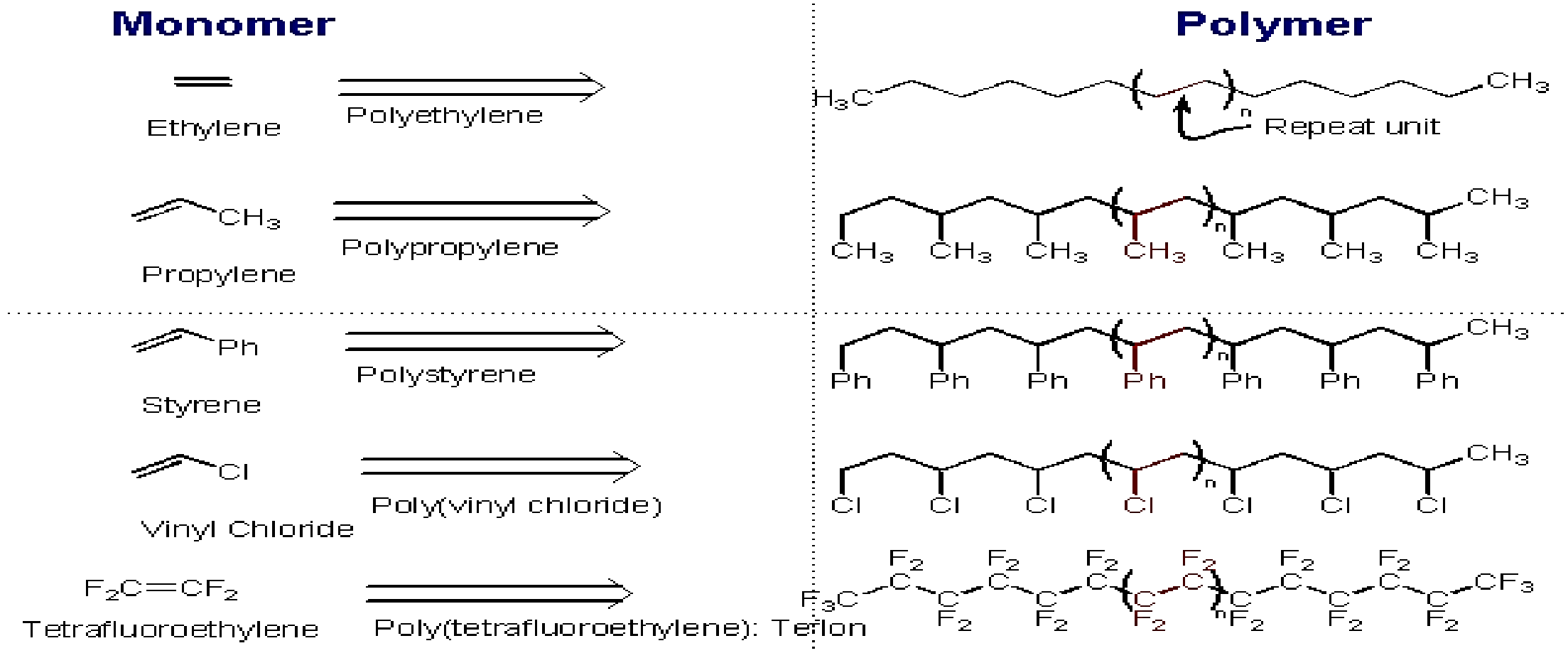




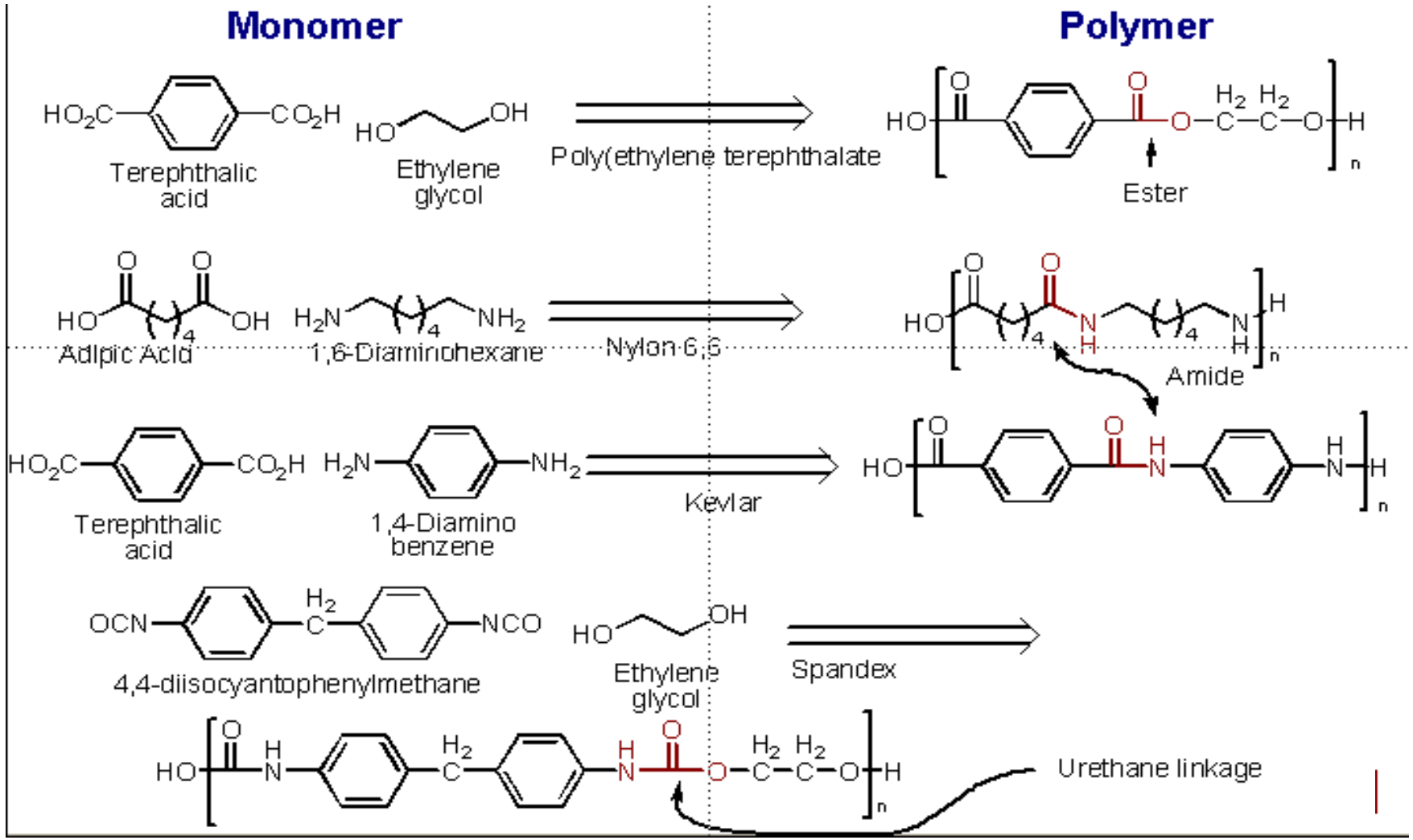
Polymer Families

- Polyolefins: made from olefin (alkene) monomers
- Polyesters, Amides, Urethanes, etc.: monomers linked by ester, amide, urethane or other functional groups
- Natural Polymers: Polysaccharides, DNA, proteins

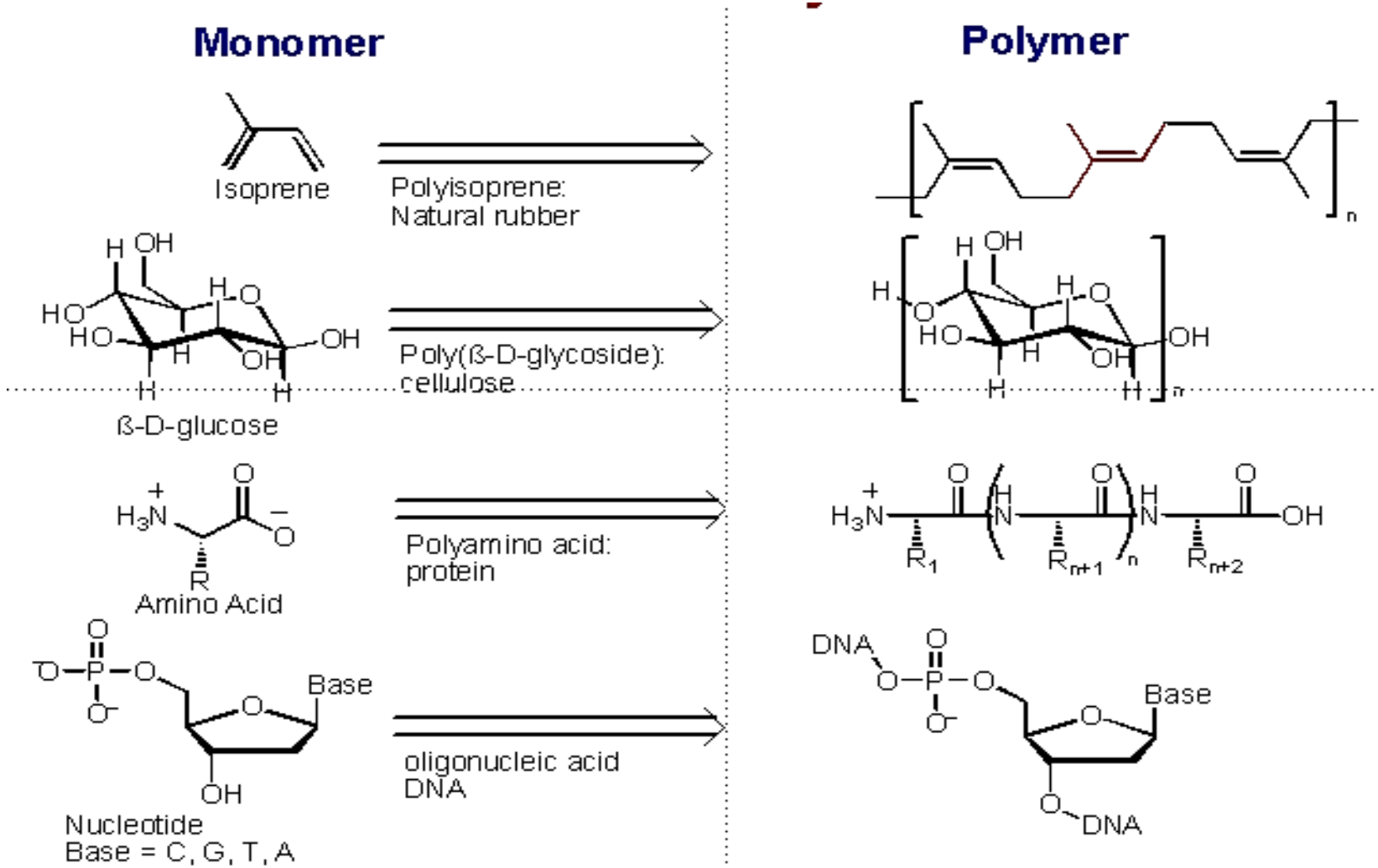
Common Polyolefins



Polyesters, Amides, and Urethanes



Natural Polymers

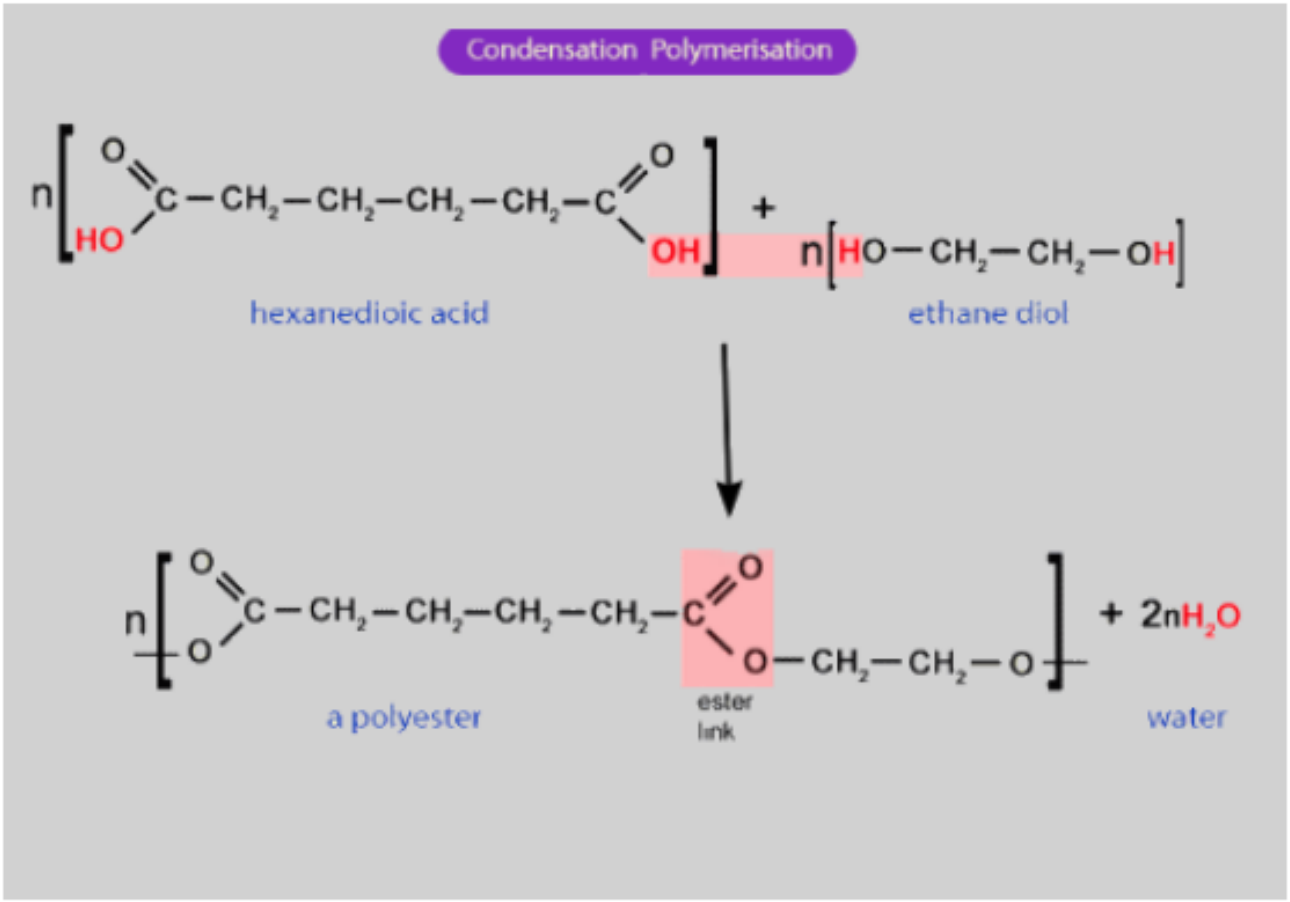


Q. What is polymerization? What are the common types of polymerization?

- Polymerization is the process of chemically joining monomer units to form a polymer chain. There are different types of polymerization processes, each characterized by the mechanism and conditions under which the monomers are polymerized. Here are some common types of polymerization:

1. Addition Polymerization: This type of polymerization occurs when unsaturated monomers, such as alkenes, undergo a chain reaction to form a polymer. The monomers add to the growing polymer chain without the elimination of any byproducts. Examples of addition polymerization include the formation of polyethylene, polypropylene, and polystyrene.

2. Condensation Polymerization: In condensation polymerization, monomers join together, releasing a small molecule like water, alcohol, or carbon dioxide as a byproduct. This reaction occurs between monomers with two different functional groups, such as carboxylic acids and alcohols. Examples of condensation polymers include nylon, polyester, and polyurethane.



✓ Learning Outcome

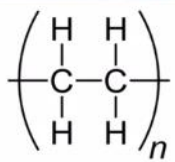
1. Assign the stereochemistry of a polymer structure – (Atactic, Isotactic etc)
2. Assign compositional features- homo, copolymer etc
3. Assign chain architecture- linear, branched, dendrimer
4. Identify type of polymerisation – (Polypropylene, Polyamide)

Industrial Application of Polymer:

Chain Length: 1000 - 2000

Low-Density Polyethylene (LDPE)

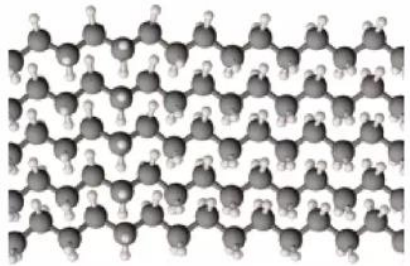
high branching , less tightly packed , and less crystalline

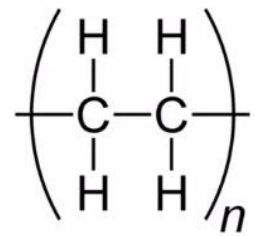


Chain Length: 10,000 - 100,000

High-Density Polyethylene (HDPE)

less branching, tightly packed, and has high tensile strength.





USES Of POLYETHYLENE

- Polyethylenes are very good insulating materials and are adequately flexible hence used as an insulator in wires and cables.
- They find extensive uses and applications as molded or formed objects, films, sheets, bottles and containers, pipes, and tubes.
- Polythene finds application in packaging, waterproofing, irrigation, and water management including canal lining and mulching, and in coating and lamination.

PP (Polypropelene)

- Addition polymer
- Thermoplastic
- Monomer propylene

USES

For making household appliances

In package industry

For making plastic parts of machinery

For making plastic furniture

For making syringes, medical vials, Petri dishes, pill containers, specimen bottles

Polystyrene: Amorphous and Transparent, Addition Polymer

- As electrical insulator.
- Expanded polystyrene finds extensive use in packaging and shock absorbing applications, in thermal insulation, and as acoustic improvers in halls and auditoria.
- High impact grades are suitable for use as toys, games and sports articles, casings and cabinets for electrical/ electronic gadgets and equipment, and inner liners of refrigerators.
- Another major use of polystyrene is in the making of ion-exchange resins.

POLYBUTENE:

- Polybutenes are used in lubricants, adhesives, sealants, coatings, rubber, oils, liquids, packaging films and a whole host of other applications.
- Liquid polybutene is also used as a thinner in the manufacture of many hot-melt adhesives (otherwise known as hot glue) at a specific melting point.
- In addition, it acts as a processing aid when added to sealants.
- Polybutene is able to enhance the adhesive properties and flexibility of glues and sealants and is often used in conjunction with resins in such applications.

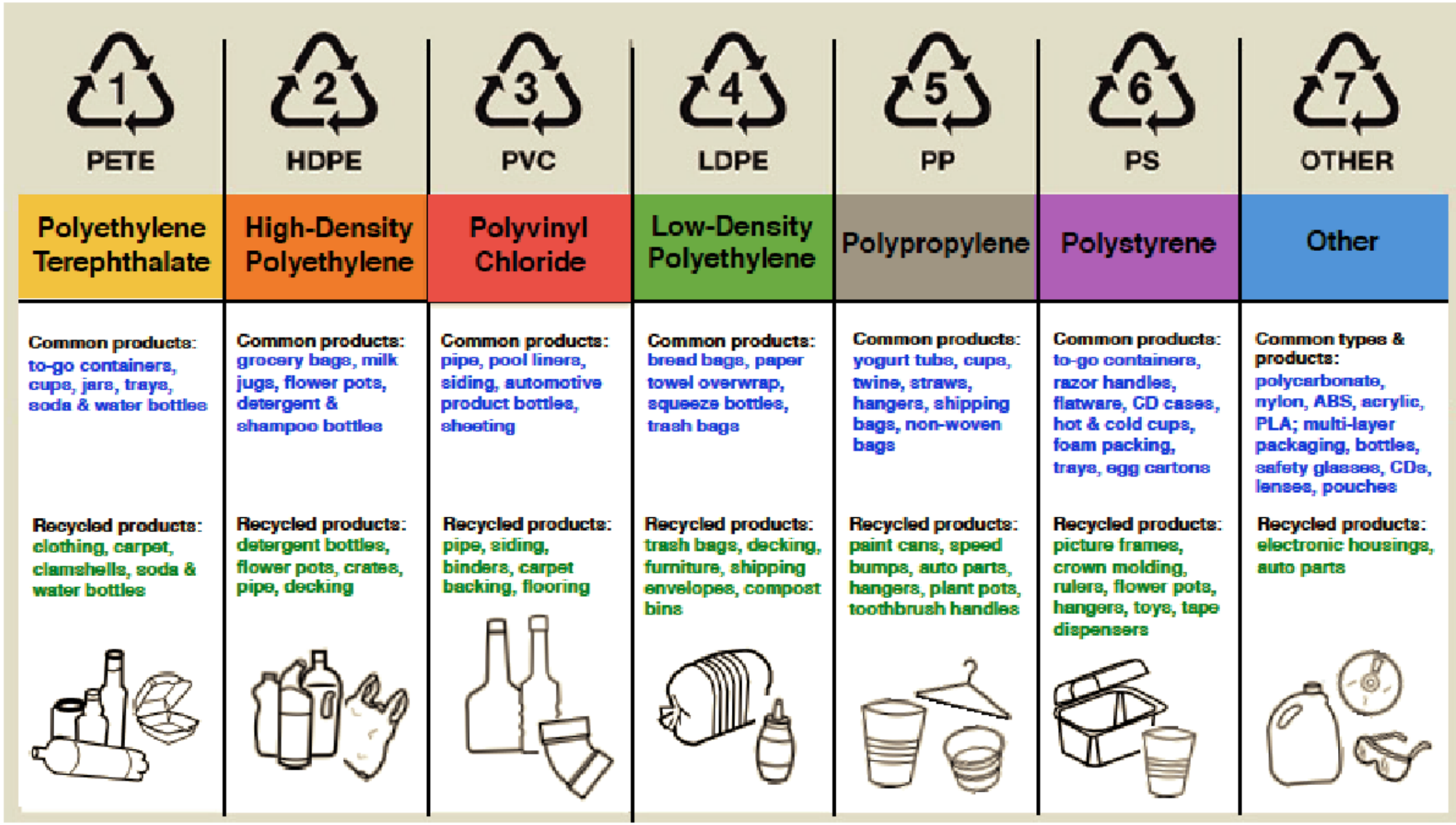


Figure 1: Plastic resin identification codes; developed by More Recycling (ARP, n.d.).

➢ Polyethylene terephthalate

- For the manufacturing of shopping bags, water bottles, videotapes.
- For manufacturing of, containers and bags.
- For the manufacturing of clothes and housing material.
- For manufacturing of water bottles.
- For manufacturing of microwaves containers.
- For the manufacturing of carpets.
- For the manufacturing of packaging films.

Kevlar:

- Para-armid fibre (aromatic polyamide)

- It is woven into textile materials and is extremely strong and lightweight, with resistance toward corrosion and heat. It is used in vast applications such as aerospace engineering (such as the body of the aircraft), body armor, bulletproof vests, car brakes, and boats.

Spandex

- It is woven into textile materials and is Spandex, Lycra, or elastane is a synthetic fiber known for its exceptional elasticity.
- It is a polyether-polyurea copolymer that was invented in 1958 by chemist Joseph Shivers at DuPont.
- Elastic material used in the fabrics of a summer cycling attire comprising a jersey, bib shorts and gloves.

https://semesters.in/introduction-and-applications-of-conducting-polymers-notes-pdf-ppt/

Some Commercially Important Polymers: Notes, Applications (embibe.com)