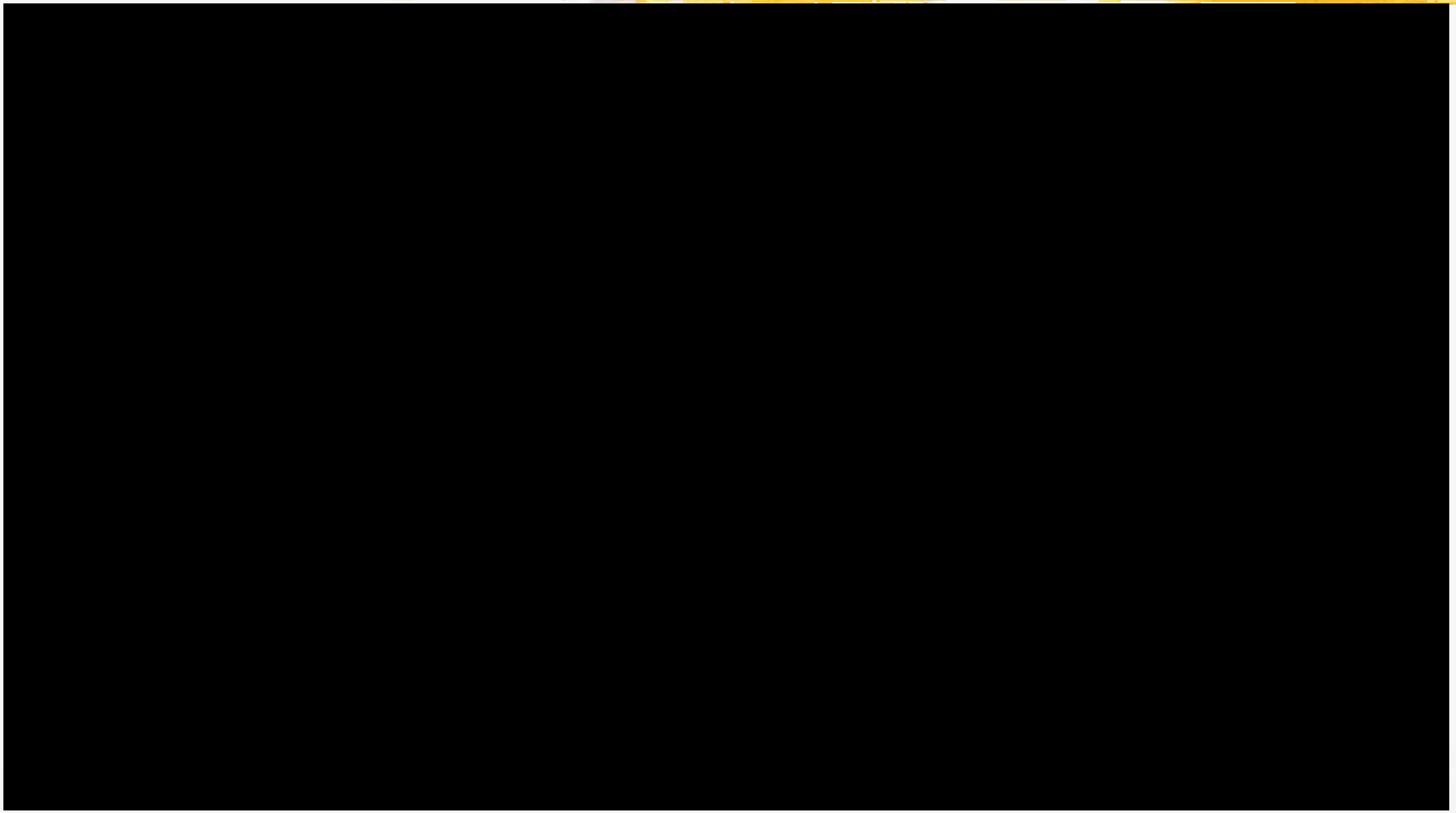
Polymers

- Polymers
- Different Types of Polymers
- Uses and Applications of Polymers

Polymer video



Polymers

- Polymers are a special kind of macromolecule
- All polymer are macromolecule but all macromolecule are not polymers
- The word polymer comes from the Greek words “poly,” meaning “many”, and “meres,” meaning “parts” or “repeating units”
- A Polymer consists of a large chain of repeating molecules (monomers) that are attached in an end to end fashion

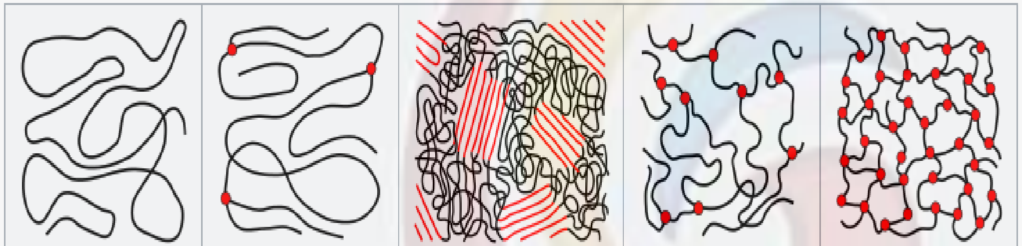
Length of Polymers

- Polymer chains are long
- Polymers consist of between 20,000 and 40,000 individual monomers
- Chain length gives the polymer most of its desirable characteristics & properties

Types of Polymers

- There are two main types of polymers
  - Natural
    - (cotton, silk, wood, leather…)
  - Synthetic
    - (plastics, nylon, latex…)

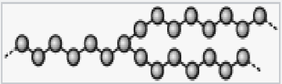
While branched and unbranched polymers are usually thermoplastics, many elastomers have a wide-meshed cross-linking between the "main chains". Close-meshed crosslinking, on the other hand, leads to thermosets. Cross-links and branches are shown as red dots in the figures. Highly branched polymers are amorphous and the molecules in the solid interact randomly.



linear, unbranched macromolecule	branched macromolecule	semi-crystalline structure of an unbranched polymer	slightly cross-linked polymer (elastomer)	highly cross-linked polymer (thermoset)

Polymer architecture

Main article: Polymer architecture



Branch point in a polymer

An important microstructural feature of a polymer is its architecture and shape, which relates to the way branch points lead to a deviation from a simple linear chain.[28] A branched polymer molecule is composed of a main chain with one or more substituent side chains or branches. Types of branched polymers include star polymers, comb polymers, polymer brushes, dendronized polymers, ladder polymers, and dendrimers.[28] There exist also two-dimensional polymers (2DP) which are composed of topologically planar repeat units. A polymer's architecture affects many of its physical properties including solution viscosity, melt viscosity, solubility in various solvents, glass-transition temperature and the size of individual polymer coils in solution. A variety of techniques may be employed for the synthesis of a polymeric material with a range of architectures, for example living polymerization.

Chain length

A common means of expressing the length of a chain is the degree of polymerization, which quantifies the number of monomers incorporated into the chain.[29][30] As with other molecules, a polymer's size may also be expressed in terms of molecular weight. Since synthetic polymerization techniques typically yield a statistical distribution of chain lengths,

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Synthetic Polymers

- There are two basic types of synthetic polymers
  - Thermoplastics (plastics, Styrofoam)
    - These can be softened by heating and hardened by cooling - easily recycled
    - Can easily be cast into various shapes
  - Thermosets (epoxy's, adhesives)
    - These harden after being heated
    - Can easily be cast into different shapes
    - Cannot be reformed

Homopolymer&Copolymer

- Most polymer chains are made up of one type of monomer (for example, red beads) these are called homopolymers
- However, some polymers are made up of different types of monomers (for example, blue and red beads) - these are called copolymers

•**Polymerization**: ***“The process by which, monomer combine to form polymers is known as polymerization”.***

***Degree of Polymerization (DP)*: *“The numbers of repeating unit present in it call degree of polymerization (DP)”*.**

Addition Polymerization: *: ‘When molecules just add on to form the polymer, the process is called ‘addition polymerization*’

In ‘addition polymerisation’ the molecular weight of the polymer is roughly equal, to that of all the molecules, which combine to form the polymer.

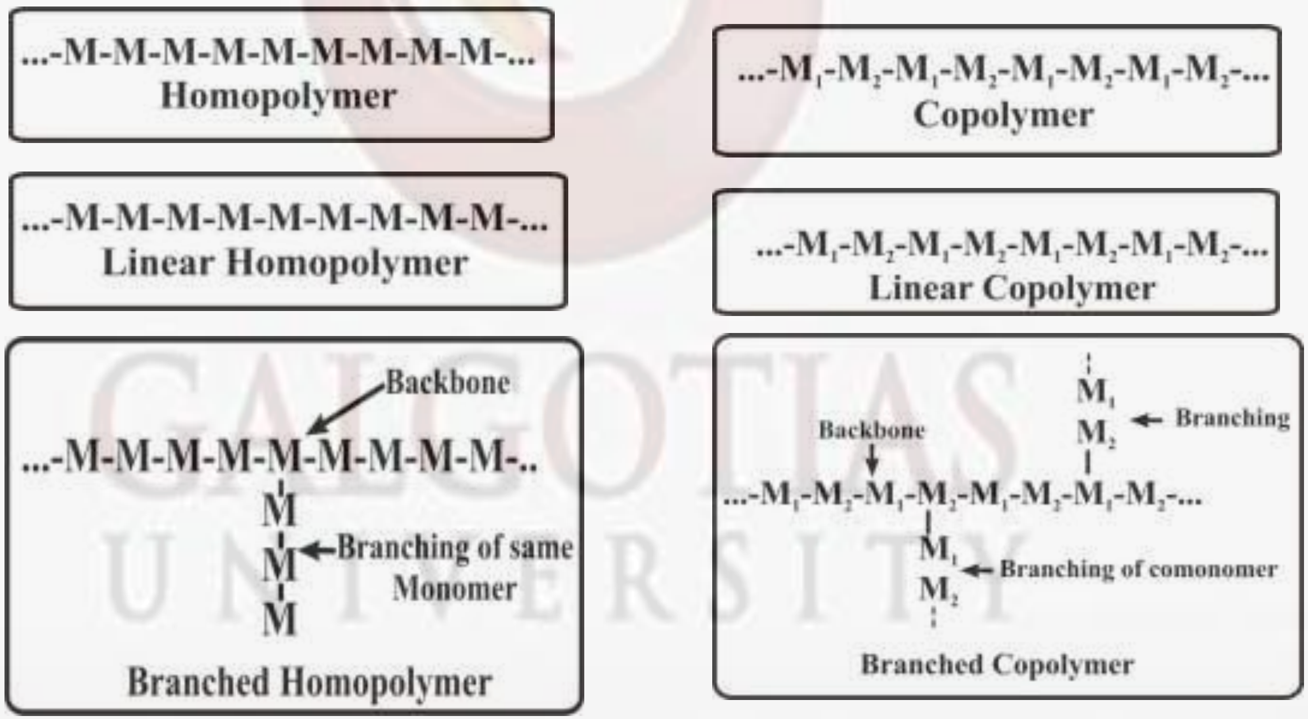
Ex; Polyethylene, polypropylene

Condensation Polymerization: When, however, molecules do not just add on but also undergo some reaction in forming the polymer, the process is called 'condensation polymerisation'

- **The molecular weight of polymer is lesser by the weight of simple molecules eliminated during the condensation process**
- **The condensation takes place between the two reactive functional groups, like the carbonyl group (of an acid) and hydroxyl group (of an alcohol) to form polyesters.**

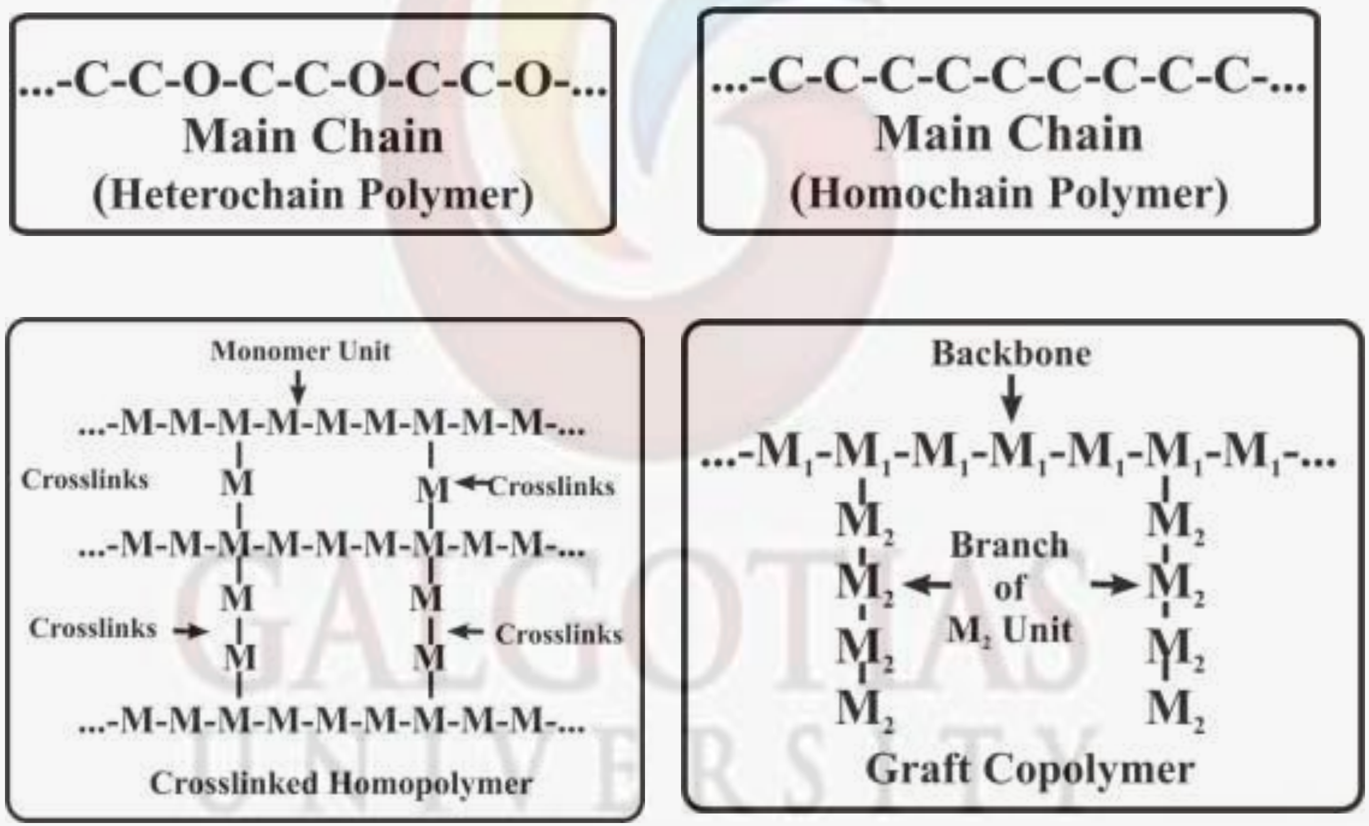
Ex. Nylon, PET

A polymer consist of identical monomers or monomers of different chemical structure and accordingly they are called homopolymer and copolymers respectively. If the main chain is made up of same species of atoms, the polymer is called 'homochain polymer' Graft copolymer are branched structures in which the monomer segments on the branches and backbone differ



The monomeric unit in a polymer may be present in a linear,

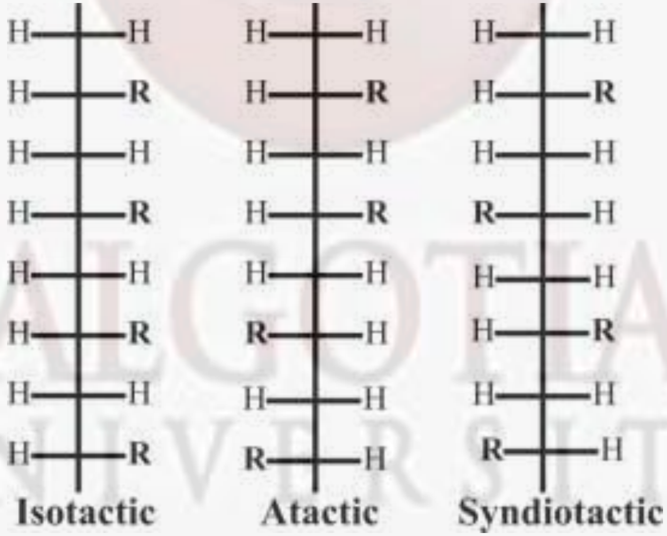
branched or cross-linked (three dimensional) structure



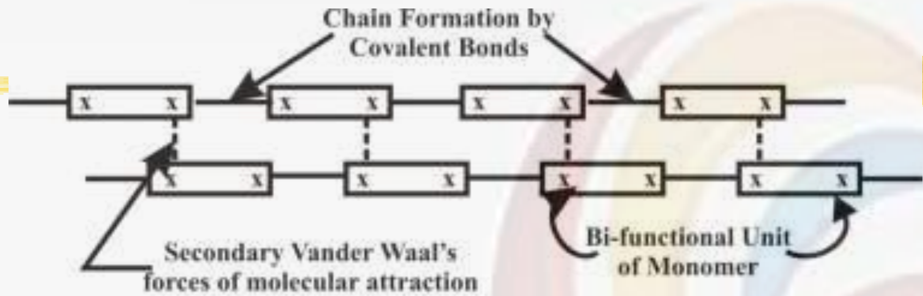
1. The head to tail configuration in which the functional groups are all on the same side of the chain, is called 'isotactic polymers'.

2. If the arrangements of functional groups are at random around the main, it is called 'atactic polymers' e.g. polypropylene.

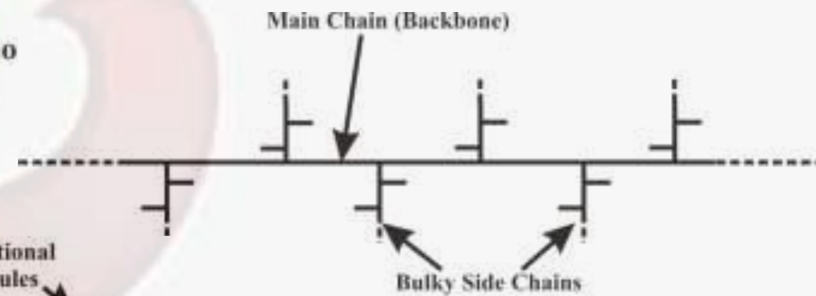
3. If the arrangements of side groups is in alternating fashion, it is called 'synditactic polymers'



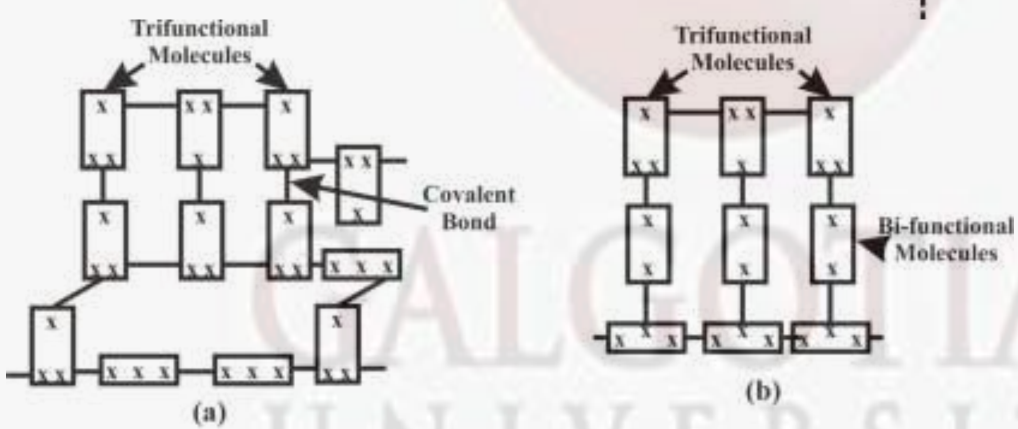
Where R = Alkyl Group



Linear Chain polymer from a bi-functional mono



Branched Chain Polymer



Formation of three dimensional network polymer
(a) reaction of three functional molecules
(b) reaction between two and three functional molecules

Thermoplastics	Thermo-settings
1. They are usually formed by addition polymerization and condensation	1. They are usually formed by condensation polymerization
2. They consist of long chain linear polymers with negligible cross-links	2. They have three dimensional network structure
3. They soften on heating readily, because secondary forces between the individual chain can break easily by heat or pressure or both	3. They cross-link and bonds retain their strength on heating and hence they do not soften on heating.
4. By reheating to a suitable to a suitable temperature, they can be softening, reshaped and thus reused.	4. They retain their shape and structure, even on heating. Hence, they cannot be reshaped and reused.
5. They are, usually, soft, weak and less brittle.	5. They are, usually, hard, strong and more brittle.
6. These can be reclaimed from waste	6. They cannot be reclaimed from waste.
7. They are, usually, soluble in some organic solvents	7. Due to strong bonds and cross-links they are insoluble in almost all organic solvents.
8. Examples: Polyethylene, Polypropylene etc.	8. Phenolic Resin, Epoxy, Polyurethans, Polyesters etc.

Uses of Polymers

- Polymers are incorporated into nearly every aspect of daily life
  - Entertainment
  - Sports
  - Clothes
  - Hobbies/Toys
  - Household products
  - Automotive

Polymers - Pros and Cons

- Polymers have many advantageous properties like….
  - Lightweight
  - Strong and durable
  - Cheap
  - Easy to manufacture
- Polymers are not biodegradable so end up producing large amounts of waste

Polymer Chemistry

- Polymer chains are made of Carbon backbone
- A monomer unit consists of a small carbon chain which are attached to the specific type of functional groups
- The functional group gives each polymer chain a new characteristics

Applications

Nowadays, synthetic polymers are used in almost all walks of life. Modern society would look very different without them. The spreading of polymer use is connected to their unique properties: low density, low cost, good thermal/electrical insulation properties, high resistance to corrosion, low-energy demanding polymer manufacture and facile processing into final products. For a given application, the properties of a polymer can be tuned or enhanced by combination with other materials, as in composites. Their application allows to save energy (lighter cars and planes, thermally insulated buildings), protect food and drinking water (packaging), save land and reduce use of fertilizers (synthetic fibres), preserve other materials (coatings), protect and save lifes (hygiene, medical applications). A representative, non-exhaustive list of applications is given below.

- Clothing, sportswear and accessories: polyester and PVC clothing, spandex, sport shoes, wetsuits, footballs and billiard balls, skis and snowboards, rackets, parachutes, sails, tents and shelters.
- Electronic and photonic technologies: organic field effect transistors (OFET), light emitting diodes (OLED) and solar cells, television components, compact discs (CD), photoresists, holography.
- Packaging and containers: films, bottles, food packaging, barrels.
- Insulation: electrical and thermal insulation, spray foams.
- Construction and structural applications: garden furniture, PVC windows, flooring, sealing, pipes.
- Paints, glues and lubricants: varnish, adhesives, dispersants, anti-graffiti coatings, antifouling coatings, non-stick surfaces, lubricants.
- Car parts: tires, bumpers, windshields, windscreen wipers, fuel tanks, car seats.
- Household items: buckets, kitchenware, toys (e.g., construction sets and Rubik's cube).
- Medical applications: blood bag, syringes, rubber gloves, surgical suture, contact lenses, prosthesis, controlled drug delivery and release, matrices for cell growth.
- Personal hygiene and healthcare: diapers using superabsorbent polymers, toothbrushes, cosmetics, shampoo, condoms.
- Security: personal protective equipment, bulletproof vests, space suits, ropes.
- Separation technologies: synthetic membranes, fuel cell membranes, filtration, ion-exchange resins.
- Money: polymer banknotes and payment cards.
- 3D printing.

Standardized nomenclature

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Summary

- Polymers are made up of repeating units called monomers
- Polymer chains can form a stronger polymeric substance through entanglements and cross-links
- Polymers are lightweight, strong, and inexpensive so incorporated in almost every aspect of life

References

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