Polymers

A **polymer** is a large molecule composed of repeating structural units. These subunits are typically connected by covalent chemical bonds. Although the term polymer is sometimes taken to refer to plastics, it actually encompasses a large class of natural and synthetic materials with a wide variety of properties.

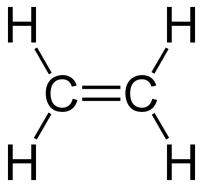
The physical properties of a polymer are strongly dependent on the size or length of the polymer chain. For example, as chain length is increased, melting and boiling temperatures increase quickly. Impact resistance also tends to increase with chain length, as does the viscosity, or resistance to flow, of the polymer in its liquid state.

Because of the extraordinary range of properties of polymers, they play an essential role in everyday life. This role ranges from familiar synthetic plastics (neoprene, PVC, nylon, synthetic rubber) to natural polymers such as nucleic acids and proteins that are essential for life.

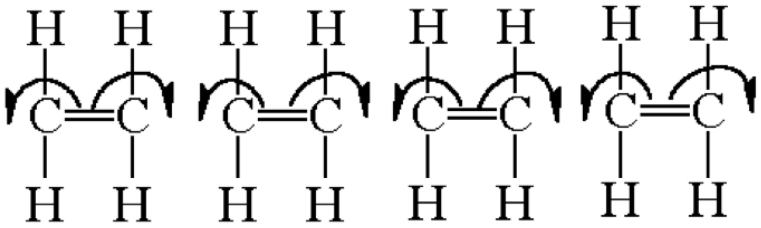
Polymerization is the process of combining many small molecules, known as **monomers**, into a covalently bonded polymer chain. There are two primary methods of polymerization: **addition polymerization** and **condensation polymerization**.

Addition Polymerization

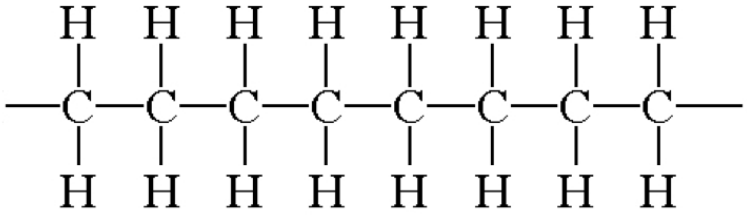
Addition polymerization begins with an unsaturated monomer that contains a double bond, such as the ethene monomer shown below.



In a catalyzed reaction, the double bond of one monomer breaks. Then one of its carbon atoms forms a single bond to a carbon atom of an adjacent monomer. This new single bond breaks the second monomer's double bond, which causes it to unite with a third monomer. The third monomer unites with a fourth, and on and on the reaction continues. This process is illustrated in the image below.



As the double bonds are broken and the monomers bond to one another, the result is a polymer chain that can be thousands of carbons long.



The polymer illustrated by this example is known as polyethylene. It is a polymer chain consisting of several thousand $-CH_2-$ groups.

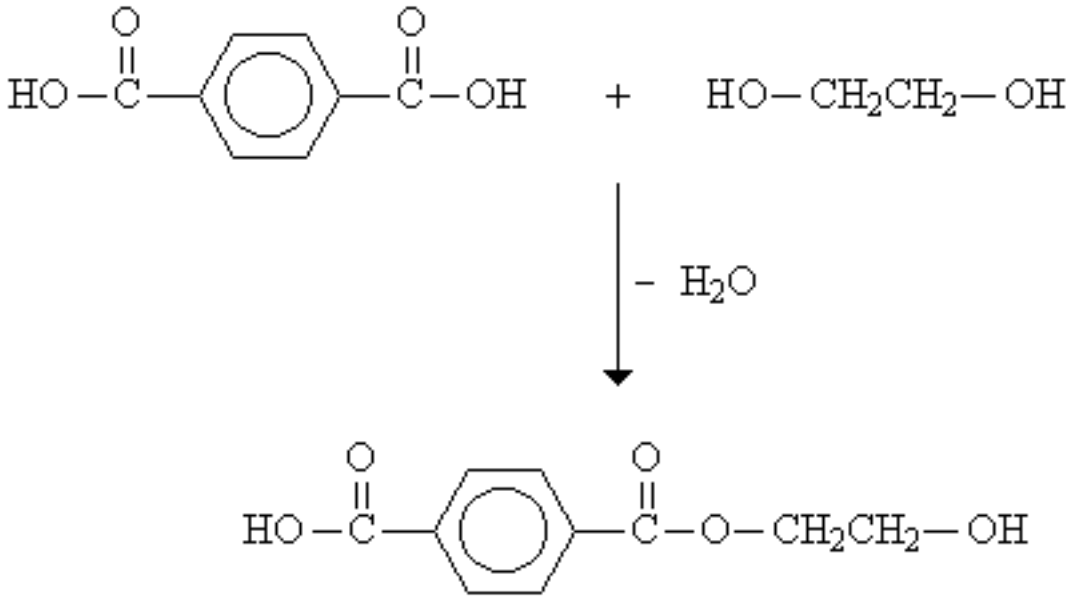
The following polymers are formed by addition polymerization:

- Polyethylene
  - film wrap, plastic bags, bottles, toys
- Polystyrene
  - toys, cabinets, foam packaging
- Teflon
  - non-stick surfaces
- Neoprene
  - synthetic rubber

Condensation Polymerization

Condensation polymers are any kind of polymers formed through a reaction that releases small molecules as by-products such as water or methanol. Types of condensation polymers include polyamides (wool, silk, nylon) and polyesters.

Condensation polymerization is a process by which two molecules join together, resulting in the loss of small molecules such as water, methanol, ammonia, or hydrochloric acid. An example of a condensation reaction is shown below.



The following polymers are formed by condensation polymerization:

- Nylon
- Dacron
    - synthetic polyester fiber
    - used in curtains, fire hoses, and dress fabrics
- Mylar
    - synthetic film
    - used as lid material on yogurt containers
    - used to wrap meat to prevent spoiling
    - used in lamination
    - used as an electrical insulating material

Cross-Linked Polymers

Cross-linked polymers are formed by linking together long chains into gigantic three-dimensional structures that are very rigid. Both addition and condensation polymers can exist with cross-linking.