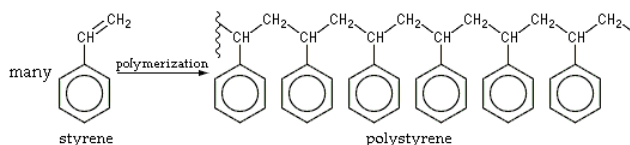


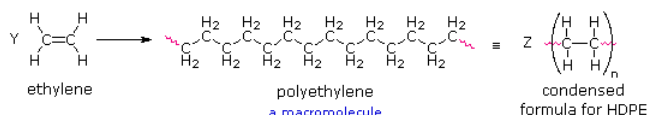
## 24.1: Introduction

**Polymers** are long chain, giant organic molecules assembled from many smaller molecules called **monomers**. Polymers consist of many repeating monomer units in long chains, sometimes with *branching* or *cross-linking* between the chains. A polymer is analogous to a necklace made from many small beads (monomers). A chemical reaction forming polymers from monomers is called **polymerization**, of which there are many types. A common name for many synthetic polymer materials is plastic, which comes from the Greek word "plastikos", suitable for molding or shaping.

In the following illustrated example, many monomers called styrene are polymerized into a long chain polymer called polystyrene. The squiggly lines indicate that the polymer molecule extends further at both the left and right ends. In fact, polymer molecules are often hundreds or thousands of monomer units long.



The repeating structural unit of most simple polymers not only reflects the monomer(s) from which the polymers are constructed, but also provides a concise means for drawing structures to represent these macromolecules. For polyethylene, arguably the simplest polymer, this is demonstrated by the following equation. Here ethylene (ethene) is the monomer, and the corresponding linear polymer is called high-density polyethylene (HDPE). HDPE is composed of macromolecules in which  $n$  ranges from 10,000 to 100,000 (molecular weight  $2 \times 10^5$  to  $3 \times 10^6$ ).



If  $Y$  and  $Z$  represent moles of monomer and polymer respectively,  $Z$  is approximately  $10^{-5} Y$ . This polymer is called polyethylene rather than polymethylene,  $(-\text{CH}_2-)_n$ , because ethylene is a stable compound (methylene is not), and it also serves as the synthetic precursor of the polymer. The two open bonds remaining at the ends of the long chain of carbons (colored magenta) are normally not specified, because the atoms or groups found there depend on the chemical process used for polymerization. The synthetic methods used to prepare this and other polymers will be described later in this chapter.

### Introduction

Many objects in daily use from packing, wrapping, and building materials include half of all polymers synthesized. Other uses include textiles, many electronic appliance casings, CD's, automobile parts, and many others are made from polymers. A quarter of the solid waste from homes is plastic materials - some of which may be recycled as shown in the table below.

Some products, such as adhesives, are made to include monomers which can be polymerized by the user in their application.

#### Polyurethane Foam



## Types of Polymers

There are many types of polymers including synthetic and natural polymers.

### Natural biopolymers

- Polypeptides in [proteins](#) - silk, collagen, keratin.
- Polysaccharides ([Carbohydrate chains](#)) - [cellulose](#), [starch](#), [glycogen](#)
- [Nucleic acids](#) - [DNA](#) and RNA

### Synthetic polymers

- Plastics
- Elastomers - solids with rubber-like qualities
  - [Rubber](#) (carbon backbone often from hydrocarbon monomers)
  - [silicones](#) (backbone of alternating silicon and oxygen atoms).
- Fibers
- Solid materials of intermediate characteristics
- Gels or viscous liquids

### Classification of Polymers

- Homopolymers: These consist of chains with identical bonding linkages to each monomer unit. This usually implies that the polymer is made from all identical monomer molecules. These may be represented as :  $-[A-A-A-A-A-A]-$  Homopolymers are commonly named by placing the prefix poly in front of the constituent monomer name. For example, polystyrene is the name for the polymer made from the monomer styrene (vinylbenzene).
- Copolymers: These consist of chains with two or more linkages usually implying two or more different types of monomer units. These may be represented as :  $-[A-B-A-B-A-B]-$

### Polymers classified by mode of polymerization

- [Addition Polymers](#): The monomer molecules bond to each other without the loss of any other atoms. Addition polymers from alkene monomers or substituted alkene monomers are the biggest groups of polymers in this class. Ring opening polymerization can occur without the loss of any small molecules.
- [Condensation Polymers](#): Usually two different monomer combine with the loss of a small molecule, usually water. Most polyesters and polyamides (nylon) are in this class of polymers. Polyurethane Foam in graphic above.

### Polymers classified by Physical Response to Heating

#### Thermoplastics

Plastics that soften when heated and become firm again when cooled. This is the more popular type of plastic because the heating and cooling may be repeated and the thermoplastic may be reformed.

#### Thermosets

These are plastics that soften when heated and can be molded, but harden permanently. They will decompose when reheated. An example is Bakelite, which is used in toasters, handles for pots and pans, dishes, electrical outlets and billiard balls.

## Contributors

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