

Topic: **Polymerization**

Objective: How do complex organic molecules form from monomers?

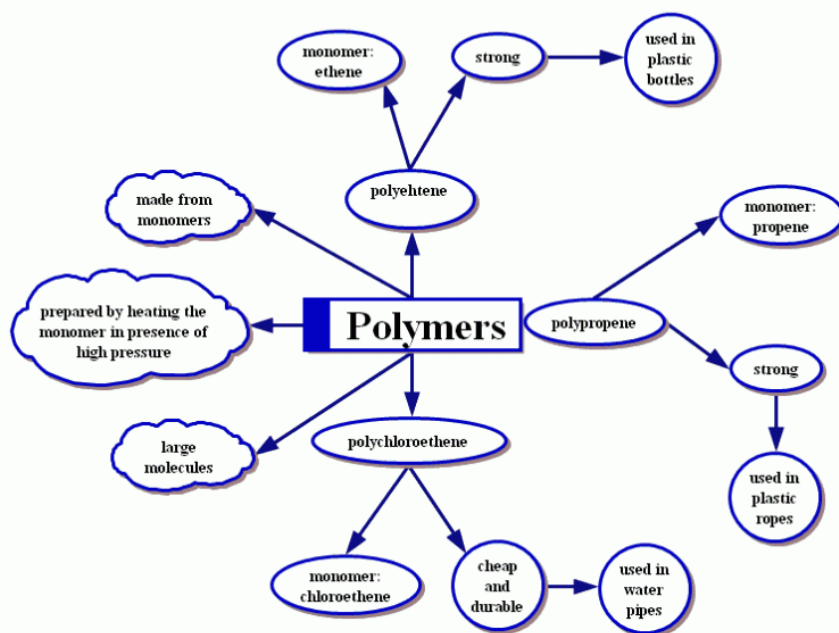
Polymerization:

- A polymer is a very large molecule made by **connecting** many **smaller** molecules (**monomers**) together. Starches are one example of natural polymers; many synthetic polymers have been made in laboratories and polymers are BIG business in industry.

- A monomer molecule may be represented by the letter 'A':



- The polymer 18 A may be abbreviated as:  $-(-A-)_{18}$ , representing a chain of 'A' monomers totaling 18 monomers in length



## Types of Polymers:

### Addition Polymers:

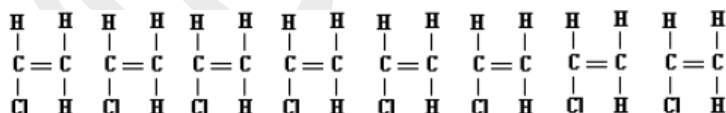
- Addition polymers are formed by an **addition** polymerization reaction.
  - The monomer's double bond opens, allowing the monomer units to join end to end.
  - The **name** of the polymer is found by putting a "**poly**" in front of the monomer unit name.

Ex: many *propylene* monomers form *polypropylene*

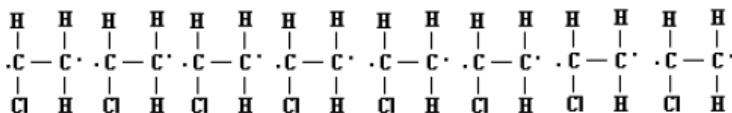
### Addition polymer examples:

#### 1. Polyvinyl chloride:

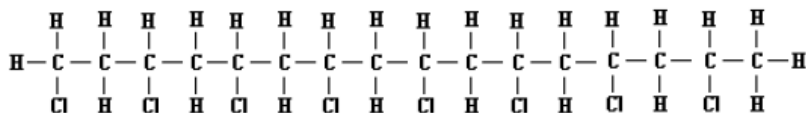
- Formed from multiple Vinyl Chloride (VC) monomers (chloroethene);
- Double bond is broken, and VC monomer units join end-to-end;
- Used in pipes, rain wear, shower curtains, vinyl siding, insulation



1) Vinyl chloride monomers, separate from each other



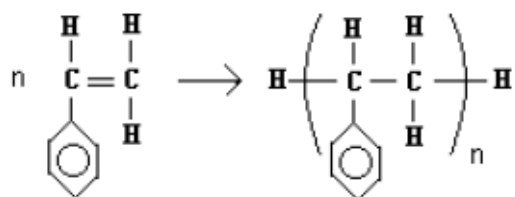
2) A catalyst breaks the double bonds, opening up a free unpaired valence electron on each C



3) The vinyl chloride monomers join end to end. The reaction is terminated by the addition of hydrogen gas, which adds on to the end of the polyvinyl chloride molecule, stopping any further polymerization.

## 2. Polystyrene:

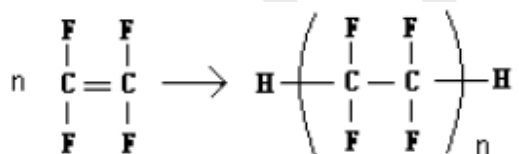
- i. Formed from multiple styrene monomers (phenylethane);
- ii. Double bond is broken, and styrene monomer units join end-to-end;
- iii. Used in plastic model kits, Styrofoam (low density)



n number of styrene monomer units combine together to form a chain of styrene monomers n units long. If you start with 2000 styrene monomer units, the polymer will be 2000 units long.

## 3. Polytetrafluoroethene (Teflon):

- i. Formed from multiple tetrafluoroethene (TFE) monomers;
- ii. Double bond is broken, and TFE monomer units join end-to-end;
- iii. Non-stick pan coating; accidental discovery in 1938



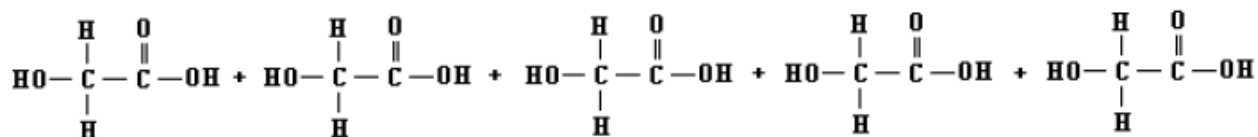
n number of TFE monomer units combine together to form a chain of TFE monomer n units long. If you start with 1500 TFE monomer units, the polymer will be 1500 units long.

Condensation Polymers:

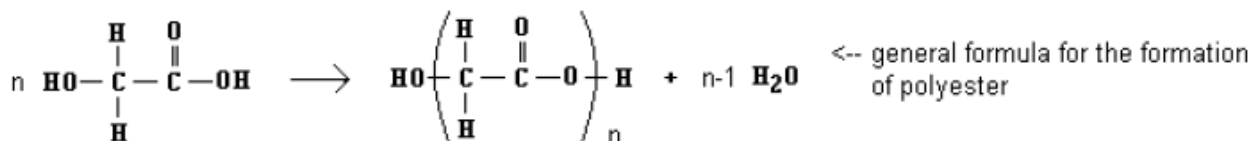
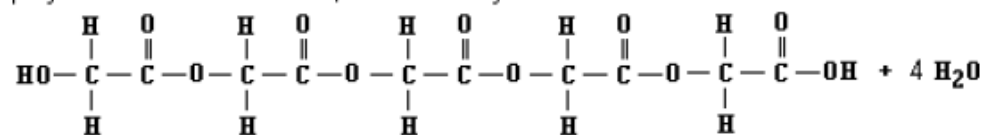
- Condensation polymers are formed by **dehydration** synthesis of difunctional (two different functional groups) monomer units.
  - H and OH are removed from the **ends** of the monomer units, allowing them to be joined together.
  - Water is the (dehydration) byproduct.

## 1. Polyester:

- Formed from a primary alcohol monomer and a primary carboxylic acid monomer;
- The opposing functional ends undergo dehydration synthesis, forming the polymer and water



The monomers above lose H and OH and bond together through dehydration synthesis to form polyester.  $n-1$  water is lost, because only the H's and OH's between the monomer units are lost.



[Watch Crash Course Chemistry Polymers YouTube video](#) - 10:14

<https://www.youtube.com/watch?v=rHxxLYzJ8Sw>