

Polymerization and Plastics

Chapter 2.1 & 2.2



Polyethylene

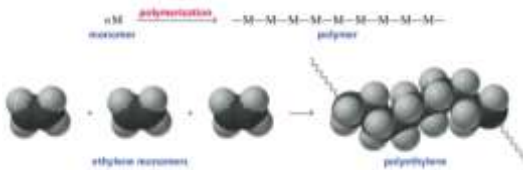
Polymers

Polymers are:

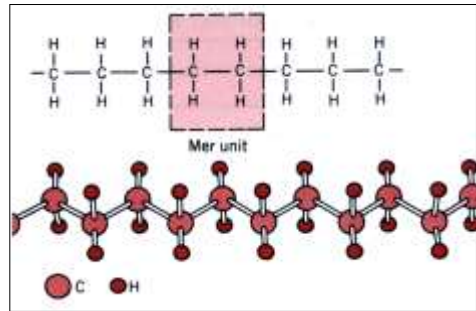
- Long-chain molecules.
- Found in nature, including cellulose in plants, starches in food, proteins and DNA in the body.
- Also synthetic such as polyethylene and polystyrene, Teflon, and nylon.

What are Polymers...

- The long chain molecule is made by linking together repeating units of small molecules called monomers



Polymer Chains and Mers

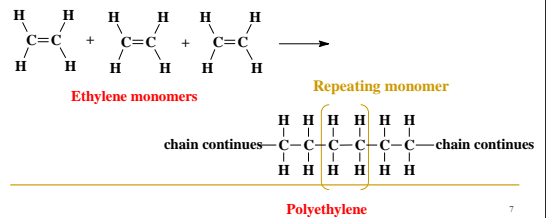


Common Synthetic Polymers



Addition Polymerization

- In addition polymerization, small repeating units called **monomers** are bonded to form the long chain polymer.



Properties of Polymers

- Crystalline: polymers line up
 - High tensile strength
 - Make good synthetic fibers
- Amorphous: polymers randomly oriented
 - Make good elastomers
- Some materials have both types of polymers mixed together
 - Flexibility and rigidity

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Polymer Structure

- Amorphous:



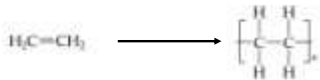
- Crystalline:



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Synthetic Polymers

- Made from monomer synthesized from fossil fuels
- First manufactured shortly before World War II
- Synthesized using addition reactions
 - Add monomer to end of polymer chain
 - Build very large polymers



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Polyethylene

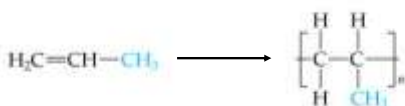
- Cheapest and simplest synthetic polymer
 - Made from $\text{CH}_2=\text{CH}_2$
 - Invented shortly before World War II
- Has two forms
 - High-density polyethylene (HDPE)
 - Low-density polyethylene (LDPE)



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Polypropylene

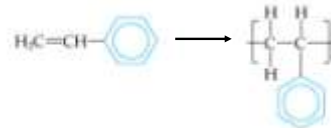
- Change a $-\text{H}$ to $-\text{CH}_3$
- Harder and has higher melting point than polyethylene



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Polystyrene

- Change a $-\text{H}$ to benzene ring
- Widely used
 - Disposable cups
 - Insulation



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Vinyl Polymers

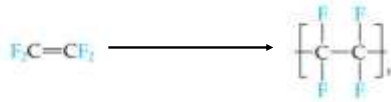
- Change a -H to -Cl
- Tough thermoplastic
 - Polyvinyl chloride (PVC)



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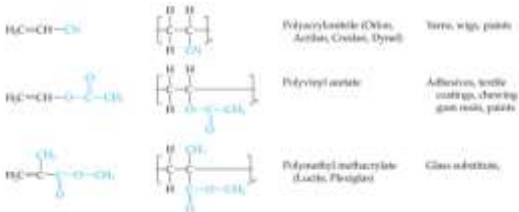
Teflon

- Change all -H to -F
 - C-F very strong. Resists heat and chemicals
 - Makes very unreactive polymer



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Other Polymers



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Recycling Plastics

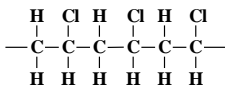
- Recycling is simplified by using codes on plastic items.
- PETE Polyethyleneterephthalate
 - HDPE High-density polyethylene
 - PV Polyvinyl chloride
 - LDPE Low-density polyethylene
 - PP Polypropylene
 - PS Polystyrene



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Learning Check

- What is the starting monomer for polyvinyl chloride (PVC)?

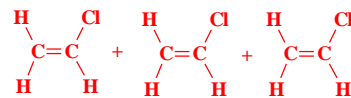


Polyvinyl chloride

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Solution

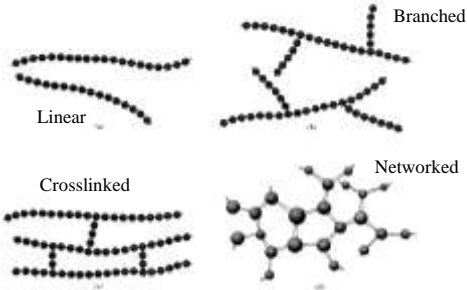
- What is the starting monomer for polyvinyl chloride (PVC)?



Chloroethene monomers

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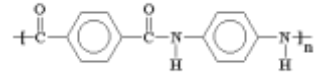
Polymer Structures



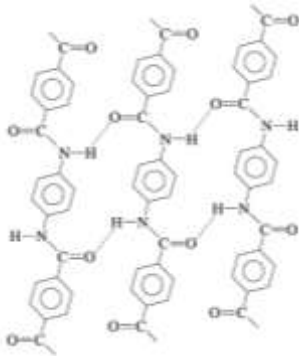
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High Performance Polymers

- **Kevlar** is a Polyamide:
- Chains are stiff and straight.
- Chains are Crosslinked via hydrogen bonding
- Highly crystalline polymer, difficult to process.
- Melting temperature 500° C
- Tensile strength 3.6 **GPa**, about 4x steel!



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Condensation Polymers

- Part of the monomer will not be incorporated into the final material
 - Typically a small molecule like water
- Formula of the repeating unit not same as monomer
- Used to produce nylon and polyesters

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Condensation Reactions

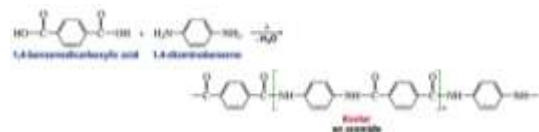
Nylon 6 is an example of a step-growth polymer formed by a monomer with two different functional groups



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Condensation Reactions

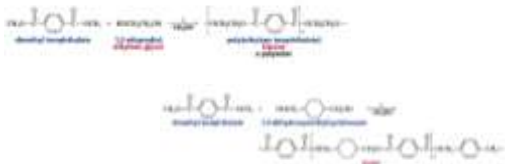
The incorporation of aromatic rings into polymers improves the physical strength of the polymers



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Condensation Reactions

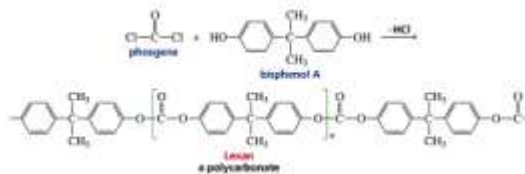
Polyesters are step-growth polymers in which the monomer units are joined together by ester groups



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Condensation Reactions

Polyesters with two ester groups bonded to the same carbon are known as polycarbonates



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