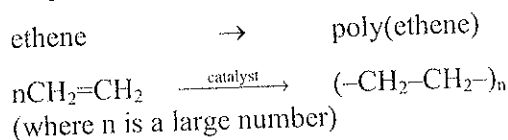


## 6 Poly(ethene)

**Poly(ethene)** is a polymer made from the monomer ethene. Poly(ethene) is also referred to as **polythene** and **polyethylene**. It is called an **addition polymer** because it is made by an addition reaction in a process called addition polymerisation.



A **monomer** is a small molecule, many of which can be joined together to form a long chain molecule called a polymer.

A **polymer** is a large molecule consisting of a large number of identical small molecules (monomers) joined together, for example plastics, rubber, synthetic textiles, starch, cellulose, protein and DNA in our genes.

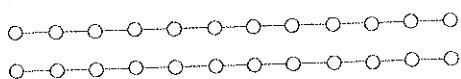
**Polymerisation** is the process of manufacturing a polymer. Commercial polymers are formed through chemical reactions in large vessels under heat and pressure and using a transition metal catalyst. Additives are used to produce the required molecular length and special properties.

**Stages in the production of poly(ethene) are:**

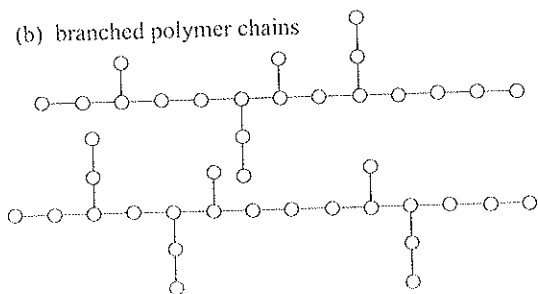
1. **Initiation** — A chemical called an initiator starts (initiates) the reaction by opening the double bond of an ethene monomer. This forms an ethene free radical. A free radical has an unpaired outer shell electron so is very active.
2. **Propagation** — The monomers join, forming a chain.
3. **Termination** — When free radical ethene chains combine, a complete polyethene molecule is formed and the process stops (it is terminated).

**Poly(ethene)** can be obtained in two forms: high-density poly(ethene), which is a linear molecule, or low-density poly(ethene), which has branched chains (see figure below). Branched molecules cannot be packed together as tightly so they tend to be less dense than polymers with linear molecules.

(a) linear polymer



(b) branched polymer chains



## Properties of Poly(ethene)

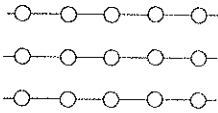
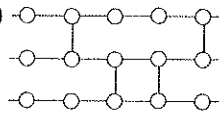
- Insoluble in water.
- Stable.
- Inert (high resistance to chemical attack).
- Easily processed into a flexible film.
- Tough and strong due to the large number of dispersion forces between the long chains and a lot of physical tangling of the chains.
- Can be repeatedly melted and formed into new shapes (a thermoplastic polymer). Thermoplastic polymers are mostly linear or only slightly branched so that in the molten state the molecules can flow past each other. Most thermoplastic polymers can be recycled.

## Uses of Poly(ethene)

Poly(ethene) is used to make thin film wrapping, supermarket bags, dry cleaning bags, garbage bags, bottles for milk, detergent and shampoo, lids, toys, mixing bowls, garbage bins, laundry baskets, boats, canoes, buoys and playground equipment as well as coatings for irrigation and sewerage pipes and telecommunications cables.

## For You To Do

1. Ethene is an important raw material for polymer production because it:  
(A) readily undergoes addition reactions  
(B) is readily hydrogenated  
(C) is less reactive than ethane  
(D) is abundant in natural reserves
2. The monomer used to form poly(ethene) is  
(A)  $-\text{CH}-\text{CH}-$   
(B)  $\text{CH}_2=\text{CH}_2$   
(C)  $(\text{CH}_2-\text{CH}_2)_n$   
(D)  $-\text{CH}_2-\text{CH}_2-$
3. The plastic formed during polymerisation depends on:  
(A) the monomers used  
(B) the number of molecules joined together and hence its molecular weight  
(C) whether the chain is branched or straight  
(D) all of the above
4. Poly(ethene) is an addition polymer. Explain the meaning of this term.
5. Outline two ways in which the long polymer chains that make up poly(ethene) give it strength.
6. Two forms of poly(ethene) are low density poly(ethene) (LDPE) and high density poly(ethene) (HDPE). LDPE is produced at much higher temperatures and pressures than HDPE.  
(a) Identify a scientific advance that made the development of the low pressure process possible.

- (b) Outline the commercial advantages of using the low pressure process.
- (c) LDPE is more flexible. HDPE is more rigid. Based on this information, deduce which product would be more suitable to use as cling wrap.
- (d) LDPE is less dense than HDPE. Which polymer would you expect to have a branched structure? Explain.
- (e) The regular packing of polymer chains in HDPE makes this plastic stronger and more rigid than LDPE. Identify which of these two types of plastic would be used for:
- sandwich bags
  - water pipes.
7. Plastics can be classified as thermoset or thermoplastic. Thermoset plastics are set into a permanent shape and cannot be softened by reheating. Thermoplastics become soft when heated and can be reshaped. Label the two diagrams below to indicate which of the following structures could represent each of these two types of plastics. Justify your answer in terms of bonding.
- (a)  (b) 
8. Polytetrafluoroethene, commonly called teflon, is a hard, tough, non-flammable polymer. The strength of its C-F bonds also make it resistant to chemical attack. Because of these properties it is used to provide a non-stick coating on such surfaces as cookware and skis. The structure of polytetrafluoroethene can be shown as:
- $$\left( \begin{array}{cc} \text{F} & \text{F} \\ | & | \\ -\text{C} & - & \text{C}- \\ | & | \\ \text{F} & \text{F} \end{array} \right)_n$$
- (a) Identify and show the structural formula of the monomer that would be used to make this polymer.
- (b) Calculate the molecular weight of this monomer.
- (c) Calculate the molecular weight of the polymer if  $n = 200$ .
- (d) Identify the type of chemical reaction used to link these monomer units together and form the polymer.
9. Draw sections of poly(ethene) chains to illustrate the following:
- linear chain
  - branched chain
  - chains linked with sulfur bonds.
10. Identify uses of poly(ethene) that depend on it having the following properties:
- insoluble in water
  - stable and inert
  - flexible film
  - tough and strong.
11. Discuss the commercial and industrial importance of poly(ethene).
12. Draw a section of a poly(ethene) chain showing three monomer units.
13. Construct an equation for the polymerisation of ethene.
14. Identify the stages in the production of a polymer such as poly(ethene). Use a flow chart to show this.
15. Check your knowledge with this quick quiz.
- What do we call a large molecule formed by many identical small molecules joined together?
  - Name the small molecule repeated many times in a polymer.
  - Name the process of making a polymer from monomers.
  - Identify the polymer made from ethene.
  - List two properties of poly(ethene).
  - State two uses of poly(ethene).
  - Identify the property of poly(ethene) which allows it to be used as cling wrap.
  - Which would be more dense, a polymer with a linear or a branched molecule?
  - A plastic that can be repeatedly melted and formed into new shapes is described as a \_\_\_\_\_ polymer.
  - What do LDPE and HDPE stand for?