CHAPTER 2 POLYMERS—PLASTICS, NYLONS, AND FOOD

Reflect on Your Learning

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1. It must be able to join with two other molecules, i.e., it must have two functional groups that will react with other functional groups.
2. Plastics are flexible, strong, mouldable, lightweight, and a large variety exists.
3. Petroleum products are mixtures of hydrocarbons. You would expect to find covalent bonds between C atoms and H atoms, and between C atoms and C atoms within plastic molecules; and van der Waals attractions between long polymer molecules.
4. Strong covalent bonds account for the strength of plastics; weak van der Waals attractions account for their nonrigid structure, mouldability, and relatively low melting points. The large variety of hydrocarbons accounts for the variety of plastics.
5. Carbohydrates (sugars and starches), function: energy and structure; proteins, enzymes, and muscles, function: DNA and RNA, genetic information; fats and oils, function: energy and insulation.

Try This Activity: It's a Plastic World

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(Sample answers)

Product	Function	Properties	Recycling code	Nonplastic alternative	Advantages/ disadvantages
toothbrush	cleaning teeth	stiff handle; pliable bristles	none	wood handle; animal-hair bristles	plastic does not promote fungal growth in wet conditions
television or computer casing	hiding and protecting electronics	very rigid; dustproof; nonconducting	none	wood	plastic is lightweight and mouldable
yogurt container	keeping moisture in	lightweight; waterproof;	base:5 lid: 4	glass jar; metal lid	glass is more easily recycled, and reusable but heavier and more easily broken
binders	keeping papers together and protected	colourful; long-lasting	none	cloth, cardboard	plastic is water-resistant

General disadvantage of plastics: petroleum products come from nonrenewable sources, and generally are not biodegradable.

2.1 SYNTHETIC ADDITION POLYMERS

PRACTICE

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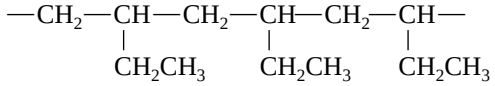
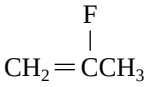
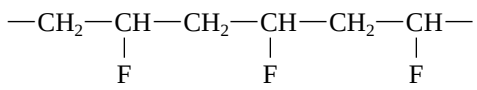
Understanding Concepts

1. 

2. 

3. 

Try This Activity: Models of Monomers

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(a) polyethene
(b) polypropene
- a molecule with more than one double bond; e.g., 1,3-butadiene

(c) 1,3-butadiene, poly-1,3-butadiene
- Each molecule must have two functional groups that can undergo condensation reactions, e.g., carboxyl group, hydroxyl group, amino group (e.g., 3-aminopropanoic acid).

Try This Activity: Skewering Balloons

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(a) The intermolecular attractions between polymer chains allow the long molecules to move aside to allow the skewer to push through without breaking, analogous to the noodles moving over each other when needed.

PRACTICE

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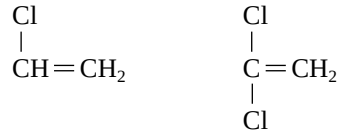
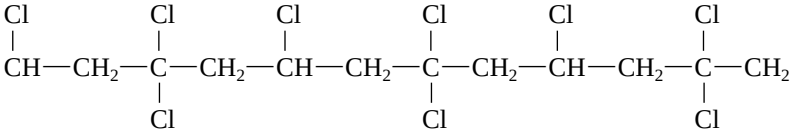
Understanding Concepts

4. Carbon–carbon double or triple bonds.
5. 

vinyl chloride 1,1-dichloroethene



SECTION 2.1 QUESTIONS

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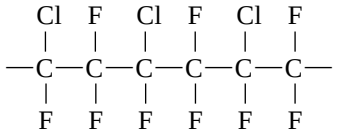
Understanding Concepts

1. (a) Intramolecular forces: covalent bonds; intermolecular forces: van der Waals forces, electrostatic attractions due to any substituted groups present, and, if crosslinking occurs, covalent bonds.
   (b) Properties of the plastics can be designed and controlled by the type of monomer used, and the type of bonding present in the polymer. The polymers are stronger than the monomers, and can be moulded by various processes, depending on the degree of crosslinking.
   (c) The double bonds in the monomers are replaced by single bonds in the polymers, resulting in the polymer having properties similar to the less reactive alkanes than the alkenes of the monomers.

2. (a)



(b) The presence of the highly electronegative Cl and F atoms makes the polymer more polar, and thus not very soluble in organic solvents. The absence of C—H bonds and the presence of the very strong C—F and C—Cl bonds makes this polymer unreactive. It is also rigid and resistant to heating.

3. (a) 2-butene
   (b) 1-chloro-1,2-difluoropropene
4. (a) The polymer that does not contain an F atom is more soluble. An F atom renders the molecule more polar and less miscible with the organic solvent.
   (b) The polymer that contains a carbonyl group is more soluble. It is more similar to acetone which also contains a carbonyl group.
5. The monomer must have more than one double bond for an addition polymer (e.g., 1,3-pentadiene).
   CH_2=CHCH=$CHCH_3$
6. (a) To be part of a condensed polymer, a molecule must have at least two functional groups that can undergo condensation reactions.
   (b) To be part of an addition polymer, a molecule must have at least one double or triple bond.
7. (a) Typical properties of plastic are flexibility, lightweight, mouldability, and electrically nonconductive. Plastics will also soften when heated.
   (b) Within long polymer molecules you would expect to find intramolecular covalent bonds. Intermolecular bonds would be van der Waals attractions. Electrostatic forces and covalent bonds would exist if crosslinking is present.
   (c) Intramolecular bonding: the prevalence of single, rather than multiple, carbon–carbon bonds makes plastics strong and chemically unreactive. Intermolecular bonding: the intermolecular attractions make the plastic strong, with the degree of crosslinking adding strength or flexibility and mouldability to the plastic.

Applying Inquiry Skills

8. Place the sample in hot water for a few minutes. If the plastic softens, it is not crosslinked and its polymer chains are held by the weak van der Waals attractions. If it does not soften by heat, its polymer chains are linked by strong covalent bonds.

Making Connections

9. (Answers may vary. One sample answer might be:) The following are accepted: code 1 (bottles for carbonated drinks, containers for peanut butter, salad dressings; code 2 (milk, water, juice bottles, grocery bags); code 4 (dry-cleaning and grocery bags, flexible containers and lids); code 5 (ketchup bottles, margarine containers); code 6 (meat trays, plastic knives, spoons, forks). Code 3 is not accepted by municipal recycling services, as they are too large for pickup, or contain medical hazards in medical tubing, etc. However, some construction pipe and siding, window frames, etc., are accepted by a nonprofit environmental program. Students will need to check their local recycling program for specific information.

   Table headings: SPI resin code; Type of products; Properties; Accepted by Municipal Recycling Organization; Accepted by Other Recycling Organization.

10. (a) (Sample answer) strong, flexible, chemically unreactive, insoluble in polar and nonpolar solvents, not softened by heat, nonbiodegradable.
    (b) (Sample answer) presence of F or Cl atoms, controlled degree of crosslinking to obtain desired flexibility and strength and resistance to heat.
11. Natural rubber is produced from the sap of the rubber tree, *Hevea brasilensis*. The sap is collected, exposed to air, and gently heated. Natural rubber is a polymer of 2-methyl-1,3-butadiene (isoprene), CH_2=C(CH_3)−CH=CH_2. The polymerization reaction is:

    $n\ CH_2$=C(CH_3)−CH=$CH_2 \rightarrow -[CH_2-C(CH_3)=CH-CH_2]_n-$

    Charles Goodyear developed the vulcanizing process in which rubber is heated with sulfur; this process produced a more elastic and stable rubber and made it suitable for a wide range of products such as cushions, mattresses, raincoats, and shoes. Rubber is primarily used in car tires, and a filler such as carbon black is added for reinforcement. Synthetic rubber was developed and produced in Germany during World War I, and demand for materials increased research and production of new synthetic rubbers during World War II.