Plastics and Modern Life

Outcomes:

- Provide examples of scientific knowledge that have resulted in the development of technologies. (111-1)
- Explain how society's needs can lead to developments in science and technology. (112-3)
- Analyse the design of a technology and the way it functions on the basis of its impact on their daily lives. (113-4)
- Make informed decisions about applications of science and technology, taking into account environmental and social advantages and disadvantages. (113-9)

Introduction

Are plastics important to you? If you are uncertain about your answer to this question, simply take a moment and look around your classroom or home and identify items that are made from plastics. You will quickly realize that plastics come in various shapes, sizes, and colours, and have various uses.

Figure 1: Many items on a teacher's desk are made from plastics.

The word "plastic" comes from the Greek word "plastikos", which means "to form". In more technical terms, plastic is a material that can be heated and molded into different shapes, which remain after it cools.

Did You Know?

Plastics are the most used materials in the world.

Before the invention of plastics, clay and glass were the only two materials that could be molded. Both were used to make containers; however, the containers were very heavy and easily breakable. Plastics were quickly admired because they were very light and strong. A person was finally able to easily transport such items as milk, juice, and shampoo in containers that if dropped, would not break.

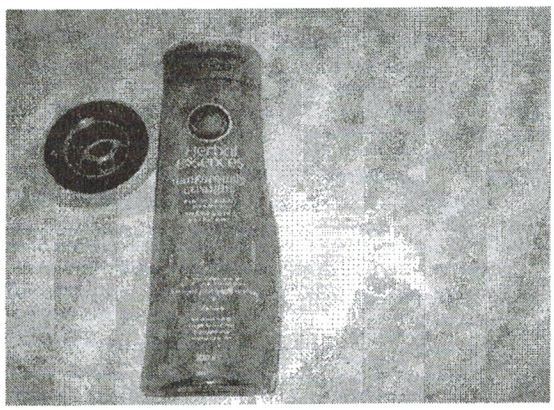


Figure 2: Dropping a plastic container of shampoo in the bathtub will not result in it breaking.

Snowmobile companies are currently competing to build machines with hoods that are both light and strong. Light translates into faster machines that can be easily lifted out of snow or lifted onto transportation vehicles (e.g. trailers). Strong translates into machines that are not easily damaged by such things as tree limbs, tree stumps, and rocks.

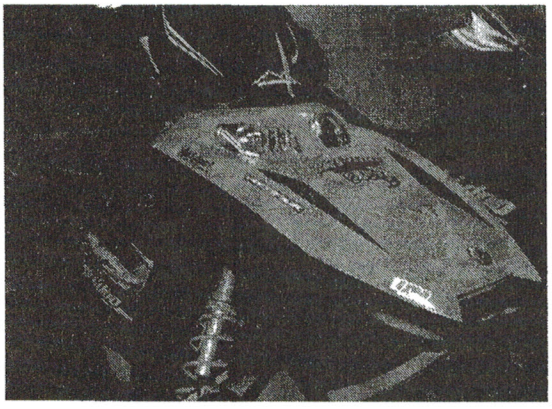


Figure 3: This snowmobile is mostly made from plastics, which results in it being both light and strong.

Natural Plastics

While most of the plastics we would recognize are synthetic, some plastics occur naturally:

1. Collagen is a protein in animals that is responsible for holding together ligaments, cartilage, and tendons. It was used by Native Americans for making tools. The twisted, spiral shape (helix) is what gives collagen its flexibility.

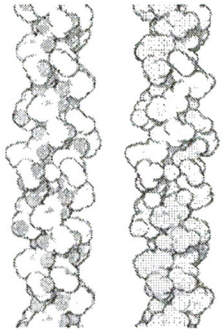


Figure 4: Two representations of what is called a collagen helix

2. Henry Ford, the famous inventor and original owner of the Ford Motor Company, experimented with soy-based plastics for making automotive parts.

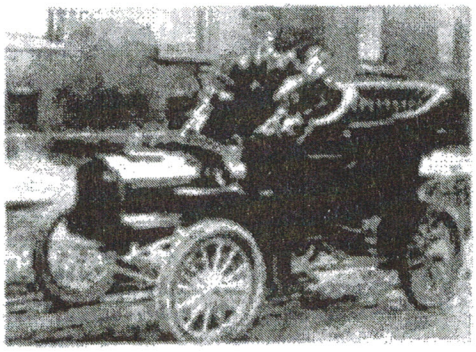


Figure 5: One of the first Ford vehicles ever made. There are automotive parts on this vehicle that are made from soy-based plastics

3. Cellophane, which is still sold and used today, is a thin transparent film made from wood pulp.

Figure 6: It is wise to wrap cold meats like salami in cellophane before storing it in the refrigerator.

Synthetic Plastics

Most plastics are human-made from oil, which is extracted from beneath Earth's surface. Oil contains molecules made up of short chains of carbon atoms which chemists refer to as monomers. Ethene (which has the chemical formula C2H4) is an example of a monomer (the prefix "mono" means "one").

Monomers can be joined together to form much larger molecules which chemists refer to as polymers (the prefix "poly" means "many"). For example, a polymer formed from the combining of ethene monomers could contain up to 300 or 400 carbon atoms depending on the type of plastic being created.

The almost endless variety of plastics that we have today is a result of the many different combinations or arrangements of monomers that are possible. Each combination of monomers creates a polymer that is used to form a plastic, which has its own unique set of physical and chemical properties. These properties enable scientists and technologists to use each type of plastic for specific purposes.

Plastic is chemically inert (i.e., will not react with other substances). As a result, it is a great material for making containers. Substances such as water, gasoline, soap, alcohol, and acid can be stored in plastic containers because the plastic and the substances will not react with each other.

Figure 7: Liquid hand soap does not react with the plastic container.

Because of their ability to be moulded into a variety of shapes, plastics can be used to make such varied things as toys, bottles, planes, clothes, computers, and bubble gum.

Did You Know?

Recent research has suggested that not all plastics are safe for storing water. Depending on the type of plastic, water may leach out (dissolve) a dangerous chemical from the plastic. To learn more about this topic, conduct research on the chemical "bisphenol a".

How Are Plastics Made?

Plastics are formed in two different chemical reactions: (1) condensation reaction and (2) addition reaction.

1. ***Condensation Reaction:*** Two monomers react with each other to form a larger molecule called a polymer. When the monomers react, two hydrogen atoms and one oxygen atom are released. These atoms recombine to form a molecule of water (H2O). It is the formation water that gives the reaction its name: condensation. The polymer that is formed can then react with another polymer to form an even larger molecule. This process can be continued until a polymer with the desired properties is attained.

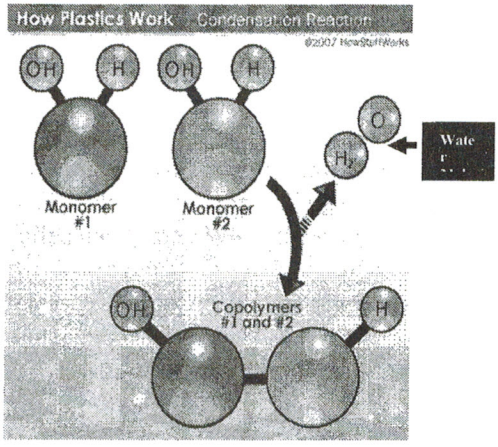


Figure 8: An illustration of a condensation reaction. Notice the formation of a polymer and a water molecule from two monomers. Illustration courtesy of HowStuffWorks, 2007.

2. ***Addition Reaction:*** Certain types of monomers react with each other to form a polymer. In this type of reaction the smaller monomers are "added" or joined together to form a long chain of monomers. The chain of monomers (i.e., polymer) can be made to specific lengths. Each of the different lengths will possess certain properties and characteristics which will allow it to be used to form different types of plastics.

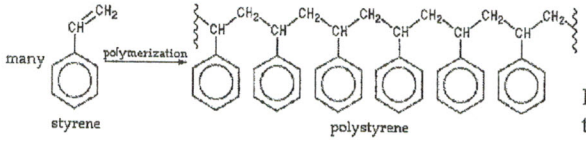


Figure 9: An illustration showing how the addition of many styrene molecules (i.e. monomers) can make a polystyrene molecule (i.e. polymer).

Types of Plastics

Plastics can be categorized into two main groups: (1) thermoset and (2) thermoplastics.

1. *Thermoset plastics* are hard and durable, and keep their shape once they have been cooled and hardened. In fact, it is impossible for them to be returned to their original forms. Examples of thermoset plastics include: polyurethane foam (e.g. sponge in chairs); polyesters (e.g. used in making clothing); and epoxy resins (e.g. a form of super strong glue).
2. *Thermoplastics* are softer than thermoset plastics. They can be softened when heated and even returned to their original forms. When heated, they are easy to mould into packaging, fibres, and films. Examples of thermoplastics include: polyethylene (e.g. plastic comprising food storage bags) and polypropylene (e.g. plastic comprising car trim and battery cases).

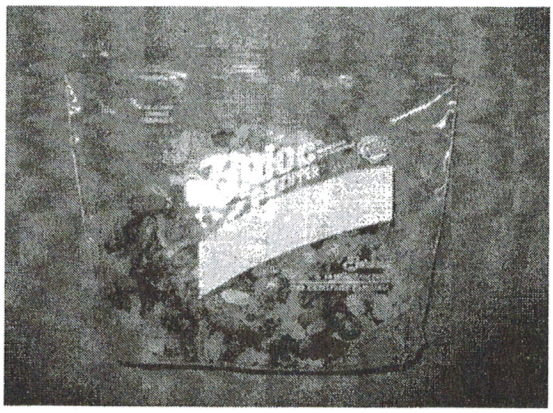


Figure 9: Freezer bags are made from polyethylene (i.e. thermoplastic).

Did You Know?

A toothbrush is composed of 11 cubic centimetres of plastic (not counting the brush). If 27 million people across Canada throw away three toothbrushes this year, this would create the equivalent of a plastic rope the thickness of your little finger that stretched all the way from Toronto to Tokyo. If we used toothbrushes with replaceable heads, we would significantly reduce the amount of plastic that will end up in the environment each year.

Cameron Smith "Let growth cater to need, not want" February 02, 2008 - Toronto Star

Some Common Synthetic Plastics

1. *Polystyrene* is made from styrene monomers. It can form hard, impact-resistant plastic, which can be used for developing such things as framing for glasses and framing for televisions. When this plastic is heated and air is blown through it, what we commonly refer to as Styrofoam® is created. Styrofoam® is the material that is often used for producing white poly bead insulation as well as disposal drinking cups and plates.

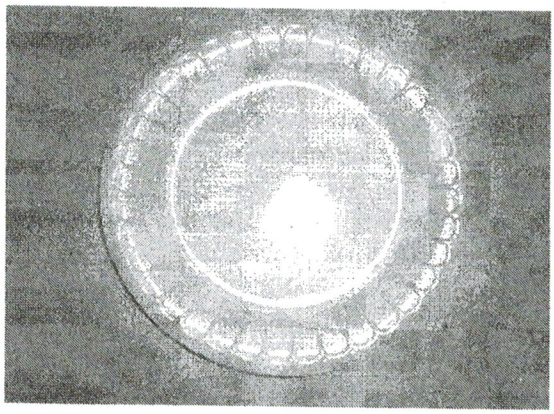


Figure 10: Disposable plates made from Styrofoam® (i.e. polystyrene).

2. *Polyvinyl Chloride* (PVC) is a thermoplastic that is formed when vinyl chloride (C2H3Cl) monomers join together. PVC is normally very hard and brittle. To make such items as the water pipes that are installed in many houses today, a chemical is added to this substance to make it soft and mouldable.

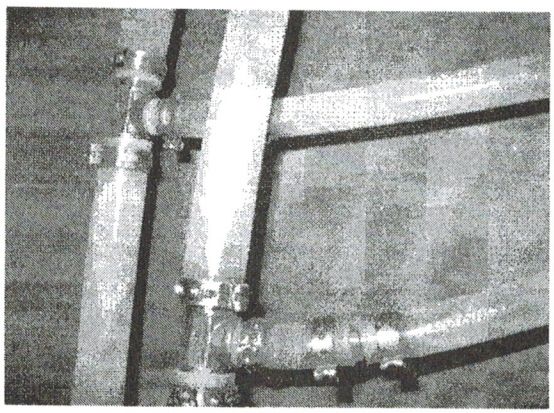


Figure 11: PVC water pipes in a recently built house.

3. *Polytetrafluoroethane* (Teflon®) is made from the combining of tetrafluoroethylene monomers (C_2F_4 ; "tetrafluoro" refers to the four fluorine atoms in each monomer). This type of plastic is strong, smooth, chemically resistant, and heat resistant. Teflon® is used in the production of such things as films and frying pans.

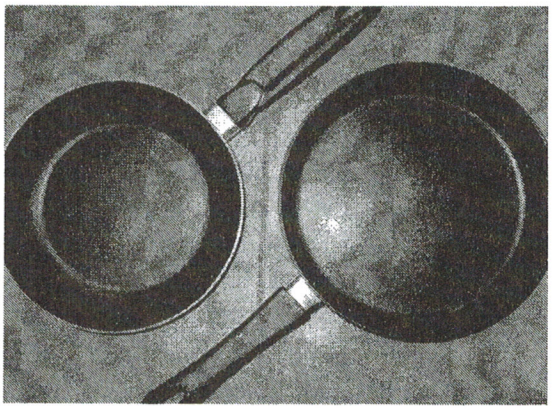


Figure 12: The surfaces of these two frying pans are made from Teflon.

4. *Polyvinylidene Chloride* is made from the combining of vinylidene chloride (C2H2Cl2) monomers. This type of plastic is made into films and wraps, which will not allow food odours to escape or enter.

Figure 13: Some plastic wraps will prevent food odours from escaping.

Conclusion

Plastics have truly revolutionized the world by improving many aspects of our daily lives. However, as with any progress, there are often some negative points or impacts to consider. Plastics do not react chemically with most things and therefore, will not decay or easily break down to environmentally-friendly compounds. As a result, throwing away plastics (e.g. shopping bags, water bottles, etc) has become a very serious environmental issue.

While recycling is often seen as a way to solve this environmental problem, the reality is that only a very small amount of plastic is recycled each year. Research is currently being done on creating "bio-degradable" plastics. For example, using corn oil instead of crude oil could produce plastics that are friendlier to the environment.

So, stop and take a moment to reconsider the question posed in the opening paragraph, "are plastics important to you"?

Questions

1. List and describe the two major types of plastics.
2. Differentiate between the four common plastics.
3. What is wrong with society using plastics? What can be done to solve (or reduce) the negative points or impacts associated with using plastics?
4. Compare the advantages and disadvantages of plastics.
5. Using examples, discuss how important plastics are to humans.
6. It has been estimated that, worldwide, there are between 500 billion and 1 trillion plastic shopping bags discarded each year. That's about 1 million bags per minute! Many businesses encourage people to use reusable shopping bags to help reduce the amount of plastic in the environment. Should we put a ban on the use plastic shopping bags? Why or why not? Defend your position by considering both sides of the argument.

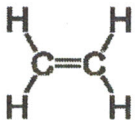
Sources of Information

The following websites relate to the topic of plastics and can be accessed for additional information:

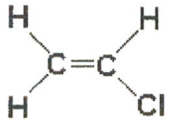
- http://www.plastics.ca/
- http://www.epa.gov/
- http://en.wikipedia.org/wiki/Plastics
- http://www.sdplastics.com/plastics.html
- http://www.sciencehowstuffworks.com/plastics

Optional Information

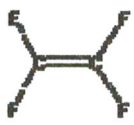
Chemists usually write the chemical formulas of substances such as ethene (C2H4). However, sometimes they draw the shape of the molecule to show how the atoms are bonded together. These are called structural formulas. The following are structural formulas of some of the chemical formulas presented above:



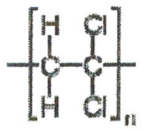
Ethene (C_2H_4). The lines between the letters represent chemical bonds between the atoms.



Polyvinyl Chloride (PVC)



A monomer of Tetrafluoroethylene.



A monomer of vinylidene chloride. This is sometimes written CH_2CCl_2. The "n" represents many monomers that would form the polymer.