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Program Support Notes

Grades 10 - College

20mins

Investigating Polymers Series

Addition Polymers

Produced by ***Rod Rees and Associates*** for ***Video Education Australasia***

Suitable for:

Chemistry

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Overview of the Program

This program is one of a series on the preparation and properties of polymers and concentrates on the addition process.

The content is aimed at Senior Secondary school students and assumes that students have a basic knowledge of molecular structure and covalent bonding. It is well presented with a wide range of polymers displayed in a meaningful way, and with clear precise molecular models showing how the different polymers are produced.

The twenty minute program begins with a surfing scene showing synthetic polymers' variety in properties – such as objects with varying rigidity, comparing those which change in melting temperature with those that will not melt, and how this relates to the polymer structure.

The student is introduced to the concept of addition polymerization using polyethylene (polythene) from ethane. Terms such as monomer and polymer are defined and simple molecular models are used to demonstrate how the double bonds in the monomers break to form the polymer. Alignment of the monomer is important for the successful formation of the polymer.

Throughout the program many examples of the different types and properties of polymers are featured. For polyethylene, using spaghetti is a clear way to explain how the molecules are aligned. This also helps explain changes in melting and cooling.

Thermoplastics are useful in that they can be used to form almost any shape, and by changing the production conditions polyethylene with different properties, such as density, can be produced. If thermoplastics are heated, some will soften and yet return to their original form when cooled.

From the basis of polyethylene, different examples of addition polymerization are demonstrated using molecular models. Examples used are polypropene, polyvinyl chloride (PVC), polyvinyl acetate (PVA) and polystyrene. Practical examples of each type of polymer are displayed in everyday use. The commonality of the single double bonds in each of the monomers is emphasized, with the different functional groups causing the changes in properties. In general the more electrons in the functional group the stronger the dispersion forces between the chain, hence the higher the melting points of the resulting polymer. (Polystyrene being an exception due to the space filling benzene functional group stops the close packing of the chains, hence a lower melting point than expected.)

Polymers can be manipulated in many ways to achieve variations in the useable products.

Vulcanization of rubber is introduced using the popular wet suit. This is produced from butadiene which has 2 double bonds compared with ethane having only one. One of the double bonds is used in the addition process while the other is then free to form crosslinks between the chains using strings of sulphur. As a result of the crosslinks, this synthetic rubber will not melt but decomposes when heated. This is an example of a thermosetting polymer, that is; one that is formed by extensive crosslinking of the monomer units when heated. If the solid is heated after setting, it does not melt but decomposes or burns.

Vulcanized rubber is used because of its elasticity for purposes such as bungy jumping and tires. When vulcanized rubber is stretched the chains become untangled and the sulphur linkages stop the chains slipping past each other. The rubber rapidly returns to its original shape when the stretching force is removed.

If the number of cross links are increased then the rigidity of the polymer increases. This makes this type of polymer suitable for uses such as car batteries or for the hard resin coating on surfboards, where hard, durable and rigid thermosetting properties are required.

Some polymers (glues, resins) can be formed by mixing the polymer with a catalyst (hardener). A catalyst is a substance which even when present in small amounts increases the rate of reaction. These are purchased in separate containers and are mixed when required.

Polymers can be deliberately modified to change their properties. PVC can be made tougher and more hardwearing by adding plasticizers. Plasticizers are usually high boiling liquids with smaller molecules compared to the polymer molecules. The small lumpy molecules hold the chains apart. When these polymers are subjected to ultra-violet light the plasticizer molecules break down. This is observed in the cracking of the vinyl roofs in cars when, over time, the plasticizers are depleted and the polymer breaks down.

Class Discussion/ activities:

1. Polystyrene cups are used for hot and cold liquids. Why is the cup light in weight and suitable for storing liquids?

   ____

   ____

2. Define and give examples of the following words:

   Covalent

   ____

   Dispersion forces

   ____

   Tetrahedron

   ____

   Catalyst

   ____

3. PVA glue (polyvinyl acetate) often smalls of vinegar and is not suitable for use in situations where it is exposed to water. Why?

   ____

   ____

Overall, this twenty minute program shows approximately 100 different addition polymers that are used in everyday life. The variations in properties can be explained by looking at the patters of bonding within the material. It gives the student a better understanding of the wide range of polymers that are used. The use of graphic representations of molecular models gives a clear understanding of how the addition process is achieved on a molecular level.

Student Worksheet

As you are viewing the program complete the following:

1. 'Poly' means ___________________________

   Mono' means ___________________________

2. Sketch a molecular model of:

   (a) ethene

   (b) polyethylene

3. Explain with a diagram how the electrons move to form bonds in addition polymerization.

4. Name 6 difference types of products made from polythene.

5. Sketch how the chains align to form polythene.

6. What is the difference between high density and low density polymers?

7. Complete the table by drawing molecular models for:

Propane	Polypropylene
Vinyl chloride	Poly vinyl chloride (PVC)
Vinyl acetate	Poly vinyl acetate (PVA)
Styrene	Polystyrene

8. a) What do all of these (in Q.7) have in common?

____

____

b) What causes them to be different?

____

____

c) Why does polystyrene have a lower melting point that expected?

____

____

9. What processes are used to make the surfboard?

____

____

10. Sketch the molecular model for butadiene and its polymer.

    Butadiene

    Poly butadiene

11. What happens when rubber is vulcanized?

12. What is the difference between thermoplastic and thermosetting polymers?

13. With vulcanized rubber, how is it changed from being elastic to a rigid solid?

14. Some resins and glues are formed by missing two different chemicals. Explain the process:

    ____

    ____

    ____

15. Plasticizers are used to make a polymer softer. On a molecular level explain how this occurs. What is the effect of ultra-violet on these polymers?

    ____

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