The structure of polymers

Specification references

* C2.2.5 Polymers
* C10.3.3 Ceramics, polymers and composites
* WS 1.4, 3.5, 3.8

Aims

The aim of this task is to extend students’ knowledge of natural polymers such as DNA, proteins, cellulose and rubber.

Learning outcomes

After completing this worksheet, students should be able to:

* name some natural polymers
* describe the monomer unit and type of linkage in some natural polymers
* describe the properties and uses of some natural polymers.

Teacher notes

This worksheet is aimed at extending students’ knowledge beyond GCSE and could be used for homework, etc.

In their technical poster on natural polymers, students should be encouraged to include as much science information as possible.

Students who are interested in the topic could be encouraged to find out more about hydrogen bonds are and why they are so important in the structure of DNA.

Task answers

An outline of possible content of students’ posters on natural polymers is given below.

**Starch/cellulose**

Starch is a condensation polymer made up of hundreds of glucose monomers; water molecules are also produced as the monomers combine. Starch is a member of the basic food group carbohydrates and is found in cereal grains and potatoes. It is also referred to as a [polysaccharide](http://www.chemistryexplained.com/knowledge/Polysaccharide.html), because it is a polymer of the [monosaccharide](http://www.chemistryexplained.com/knowledge/Monosaccharide.html) glucose. Starch includes two types of glucose polymers, amylose and amylopectin.

Cellulose is the most abundant organic compound on Earth, and its purest natural form is cotton. The woody parts of trees, the paper we make from them, and the supporting material in plants and leaves are also mainly cellulose. Like amylose, it is a polymer made from glucose monomers. The difference between cellulose and amylose lies in the bonding between the glucose units. The bonding angles around the oxygen atoms connecting the glucose rings are each 180° in cellulose, and 120° in amylose. This subtle structural difference is the reason we cannot digest cellulose.

**Proteins**

Proteins are condensation polymers of amino acids. The human body is estimated to have 100 000 different proteins, all derived from only 20 amino acids. They are formed by a condensation reaction, where two amino acids are linked, by eliminating a molecule of water as a bond forms between the carboxylic acid of one amino acid and the amine group of the other. The result is a peptide bond; hence, proteins are polypeptides containing from approximately 50 to thousands of amino acid residues.

**DNA/RNA**

Nucleic acids are condensation polymers. Each monomer unit in these polymers is composed of one of two simple sugars, one phosphoric acid group, and one of a group of heterocyclic nitrogen compounds that behave chemically as bases. Nucleic acids are of two types: deoxyribonucleic acid (DNA), and [ribonucleic acid](http://www.chemistryexplained.com/knowledge/RNA.html) (RNA). The monomers used to make DNA and RNA are called nucleotides. DNA nucleotides are made up of a phosphate group, a deoxyribose sugar, and one of four different bases: adenine, cytosine, guanine, or thymine.

**Rubber**

Natural rubber is an addition polymer made up of thousands of isoprene monomer repeating units. It is obtained from the Hevea brasiliensis tree in the form of latex.

Answers

1 a Any two relevant points: both glucose monomer units/both condensation polymers/both eliminate water molecules when they form. (*2 marks*)

 b Different structure polymers; starch can be digested, cellulose cannot (*2 marks*)

2 a Adenine/cytosine/guanine/thymine (*4 marks*)

 b DNA consists chains of nucleotides wound into a double helix coil (*2 marks*)

3 a Rubber (*1 mark*)

 b **** (*1 mark*)

4 In a protein, each amino acid has both an amine group (1) and a carboxylic acid group. (1) So, the amine group of one amino acid can react with the carboxylic acid group of another. (1) A molecule of water is eliminated and a condensation polymer can begin to form. (1) (*4 marks*)