5.1 What is a polymer?

Lesson outcomes

At the end of this activity students will be able to:

- discuss the replacement of traditional materials with plastics
- recall that polymers are composed of repeating monomer units
- present ideas to a specific audience using appropriate scientific language.

Key vocabulary:

Monomer, polymer, polymerisation, celluloid, Bakelite.

Equipment list

Each STUDENT will require:

- *Science by Doing Student Digital.*

Each GROUP will require:

- box of paper clips
- presentation materials e.g. butcher paper, video camera.

Things to consider and hints for success

This lesson should broadly consider what plastics are and their dominance in todays' products. Use the stimulus material in the guide and the clothes students are wearing, as well as classroom items in an introductory brainstorm.

Ask students their ideas first, then explore ideas like:

- carbon from trees, which grows branches with leaves – reflecting imagery for carbon chain (polymers)
- branch of chemistry called organic chemistry
- variety of trees (colour and shape)
- variety of plastics – yet fundamentally based on carbon
- the irony of wood (fundamental material) versus plastic (modern material) – simplest organic material versus complex plastics – both based on carbon
- wood glue – adhesive for wood is in fact a polymer
- jewellery on tree – plastic beads/wood beads – different colours/shapes/patterns.

The students will come up with more – and this will help them to visualise polymers.

This lesson can readily be split into two shorter periods.

Links

- **Science of synthetic polymers** (4'19' Explores the development of synthetic polymers – Bakelite, celluloid and nylon. Classification of polymers as thermosetting or thermoplastic is explained.
- **Explosives and celluloid** (3'34"): Imagine if modern explosives were still based on the smoky gunpowder used in the 19th century! Watch a re-enactment of the accidental discovery of cellulose nitrate, an explosive polymer. Find out how a scarcity of elephants launched chemists into a new world of polymer science.

- **Polymers in daily life** (1’58”): summarises a polymer, their physical properties and how we use them.

Lesson plan

Step 1: Brainstorm how plastics replaced traditional materials, using the stimulus material in the guide.

Step 2: Use the paper clip model to introduce the structure of polymers. Follow this with the digital drop-and-drag activity and the video clips *Polymer party* and *Polymers are everywhere*. Students then answer ***Notebook*** Q1-5.

Suggested questions:

- Why do you think cellulose was one of the first substances used to manufacture plastics?
- What were the advantages/disadvantage of celluloid over traditional materials?
- Why was Bakelite so successful?

5.2 Plastic from petroleum

Lesson outcomes

At the end of this activity students will be able to:

- describe catalytic cracking as a process used to make shorter, more useful, polymers from petroleum
- use models to represent polymers.

Key vocabulary:

Catalytic cracking.

Equipment list

Each GROUP will require:

- molecular model kit
- *Science by Doing Student Digital.*

Things to consider and hints for success

Links

- **Hydrocarbon cracking** (3'48"): video of the process of cracking and why it is done, including equations.
- **Alkenes, alkynes and benzene** (4.14'): Explains the structure of double and triple bonds and some uses of these compounds.
- **Bitesize: polymers** (webpage) – revises main points, video of polythene formation and questions.
- **Polymers of chloroethene and propene** (3'37"): how to draw the formula of polymers, including poly-chloroethene and poly-propene and describes some uses.

Lesson plan

Step 1: Introduce cracking to produce larger amounts of the compounds required by industry (see *Science by Doing Student Guide*). The video 'Hydrocarbon cracking' can be used here (see Links) and ***Notebook*** Q1 can be answered.

Step 2: The class combines to make models of polymers in the activity 'Making polythene'. This can be consolidated by using the digital interactive.

Step 3: The digital links are used to answer ***Notebook*** Q2-5, with group discussion of answers.

Suggested questions:

- What does the term cracking suggest?
- What is the role of a catalyst in this process?
- Which fractions of petroleum do you think we use most of?

5.3 Polymer properties

Lesson outcomes

At the end of this activity students will be able to:

- recognise that plastics have replaced traditional materials for many purposes
- describe possible environmental problems of plastics.
- discuss how changing the structure of a polymer can lead to changes in properties
- complete a first-hand investigation comparing properties of common polymers
- investigate the processes involved in making new materials from synthetic fibres
- select information from secondary sources and present for a specific purpose.

What ideas might your students already have?

Students will have some understanding of the varying properties of plastics and have experience of recycling, but may not be aware of the symbols indicating different plastics.

Key vocabulary:

Thermosoftening, thermosetting, cross-linking, plasticiser.

Equipment list

Each GROUP will require:

- box of paper clips.
- butcher paper and writing materials
- *Science by Doing Student Digital.*

For testing plastics:

- pieces of plastic l(about 4 cm2) labelled A-G: HDPE - milk bottles, LDPE – cling wrap, PET – soft drink bottles, PP – microwave food containers, PS foam – foam cups, PS solid – clear disposable cups, PVC – plastic cards (credit cards) or raincoat.
- metal tongs
- Bunsen burner
- bench mat
- 250 mL beaker
- dropper bottle of turpentine.

Things to consider and hints for success

This is a long lesson that can readily be split into shorter periods. Assigning polymers for the group poster will ensure a variety of different plastics are presented.

Links

Find out more

- **How it's made - plastic bags** (4'50"): shows manufacture of plastic bags from polythene (polyethylene), including zip-lock and bags with handles.
- **How it's made - plastic bottles and jars** (4'49"): bottle manufacture and advantages of plastic bottles.
- **How to make plastic cups and cutlery** (4'50'): Shows manufacture of disposable cups and cutlery from polystyrene.

Lesson plan

Step 1: Use the stimulus material in the *Science by Doing Student Guide* to look at differences in structure in plastics for different purposes (thermosoftening and thermosetting), including using models (see page 63 of the guide).

Step 2: Students test plastics in groups, following the instructions in the guide and use the key provided to identify the types of polymer.

Step 3: Students work in groups to identify plastics used for specific purposes in the kitchen, as illustrated in the guide.

Step 4: Discuss the symbols for different polymers and how changes in properties can be made by modifying the ethene monomer (*Student Guide* page 65). Explore the interactive in the *Science by Doing Student Digital* to link properties to uses.

Step 5: Students work in groups to explore the digital links and answer ***Notebook*** Q1-3.

Step 6: Groups make a poster on a specific polymer (***Notebook*** Q4).

Follow up:

Students will carry out a first-hand activity to change the properties of a polymer in **Activity 5.4**.

5.4 Making polymers

Lesson outcomes

At the end of this activity students will be able to:

- plan and complete an investigation to compare the properties of polymers
- describe relationships between data obtained and changes in variables in a first-hand investigation.

What ideas might your students already have?

Students should be aware that properties of polymers can be changed with different additives from earlier activities in **Part 5**.

Equipment list

Each GROUP will require:

- PVAC wood glue
- borax
- salt
- cornflour
- baking powder
- sugar (sucrose)
- 100 mL measuring cylinder
- 2 x 250 mL beakers
- 5 petri dish halves
- source of hot tap water
- stirring rod
- teaspoon
- source of hot tap water
- marking pen.

Things to consider and hints for success

As wood glue is an emulsion of a polymer, polyvinyl acetate (PVAC), this activity concerns using additives to change the properties of a polymer, rather than creating one.

If time is limited, each group could make the plain polymers and then one with a different additive and share results. Food colouring can be added.

Lesson plan

Step 1: Review what students know about how the properties of polymers can be changed.

Step 2: Students work in groups to make polymers (see **Things to consider and hints for success**).

Step 3: Students test the polymers to compare properties and think of possible uses.

5.5 Natural polymers

Lesson outcomes

At the end of this activity students will be able to:

- recall there are many natural polymers produced by living organisms
- discuss the potential of cellulose as a source of useful biopolymers
- recognise that biodegradable plastics benefit the environment
- discuss the importance of chemical reactions in the production of a range of substances, and the influence of society on the development of new materials.

What ideas might your students already have?

Students may not have extended their thinking to realise that many biological molecules they have learnt about and hear about in everyday life are also polymers.

Key vocabulary:

Biopolymer, cellulose, biomass, biodegradable

Equipment list

Each GROUP will require:

- 3 tsp cornflour (corn starch)
- 1 tsp glycerol (glycerine)
- 1 tsp white vinegar
- 250 mL beaker
- 100 mL measuring cylinder
- teaspoon
- hotplate
- stirring rod
- sheet of aluminium foil
- flat spatula
- food colouring (optional).

Each STUDENT will require:

- *Science by Doing Student Digital.*

Things to consider and hints for success:

This lesson could readily be split into two shorter periods.

Why use polymers?

Demonstration of solubility of starch polymers (see *Science by Doing Student Guide*). The purple moulded liner in Cadbury chocolate boxes could be cut up to demonstrate it will dissolve readily (is biodegradable).

Making biopolymers: You are advised to try this before teaching. The recipe is based on this home experiment: Make your own bioplastic (3'30").
http://www.youtube.com/watch?v=5M_eDLyfzp8

Link

- **Polylactic acid products**: (2011) webpage featuring biodegradable plastics made from polylactic acid (PLA).

Lesson plan

Step 1: Use the stimulus material in the *Teacher Guide* to answer the question: 'What is a biopolymer?'

Step 2: Simple experiment with starch polymer in water (see **things to consider and hints for success** and page 68 of the *Science by Doing Student Guide*).

Step 3: Students in groups of two or three make a biopolymer, following instructions in the guide.

Step 4: Class summary/discussion of results and questions.

Step 5: Explore the possibilities of cellulose as a biopolymer using the stimulus material on page 68 of the *Science by Doing Student Guide* and the digital interactive.

Step 6: Students use the digital resources to answer ***Notebook*** questions.

5.6 Recycling

Lesson outcomes

At the end of this activity students will be able to:

- design and complete a field investigation on recycling in the community
- combine research using primary and secondary sources
- present research findings in an oral or written report
- give examples of how the values and needs of contemporary society can influence the focus of scientific research.

What ideas might your students already have?

Students will have some understanding of household recycling from home and previous studies.

Equipment list

Each GROUP will require:

Requirements will vary with choice of task but may include:

- camera (or phone)
- video camera
- clipboard
- printed questionnaires.

Each STUDENT will require:

- excursion permission note
- *Science by Doing Student Digital.*

Things to consider and hints for success

This activity will require an introductory planning lesson and an excursion. The report can be written up for homework, possibly as an assessment task. Students could work in pairs to plan and collect information, but should write individual reports.

Link

- **Catalyst ABC TV - Plastic oceans** (12'18"): plastic and synthetic materials are the most common types of debris in our oceans, with horrific impacts on marine wildlife and systems. As an island continent, marine debris is of particular importance for Australia. Creatures get entangled in plastics and drown and ingested concentrated toxins from plastics pose a threat to the health of the food chain. Plastics also transport and introduce species into new environments. Anja Taylor catches up with the CSIRO research team spearheading the Marine Debris Survey, a world-first study of the plastics around our coastline.

Lesson plan

Step 1: Consider what we recycle, using the stimulus material in the *Science by Doing Student Guide* and interactive material in the *Science by Doing Student Digital*.

Step 2: Explain the purpose of the excursion and task (see the guide) so student pairs can plan their investigations. Plans, questionnaires etc. could be finished for homework prior to the excursion.

Step 3: Students consolidate their ideas about recycling using the digital resources and compete the ***Notebook*** questions.

Step 4: Excursion to recycling centre.

Step 5: Report submitted (homework or assessment task).

Suggested question/s:

- Are your questions clear and simple?
- Who will you ask?
- How will you collect the information? E.g. survey, audio or video interview.
- Do the questions cover everything you need to know?
- Can you do what you have planned in the available time?
- Have you made a list of all the equipment you will need?

5.7 Sample test

A sample summative test and a marking scheme have been developed and are available to teachers from *Science by Doing* at sbd@science.org.au. Both are editable versions, so you can adapt them to your students' needs.

Note - *Science by Doing* provides sample assessment items and whilst every effort has been made, the security of these items cannot be guaranteed. *Science by Doing* encourages teachers to modify the items to suit individual teaching programs.

Acknowledgements

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This resource was originally written in 2015 by Dr Kerrie Wilde and Dr Brenda Grieve.

This resource was revised in 2018 by Jef Byrne and Dr Jim Woolnough.

Science by Doing would like to thank Spinks and Suns for the design and development of this resource.

Acknowledgement of assistance

The following people also assisted in the production of this resource:

Stephen Ford
Students and staff at St Mary's Star of the Sea College, Wollongong
Derek Muller, Veritasium

Funding Acknowledgement

Science by Doing is supported by the Australian Government.

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Chemical Patterns, Lesson Plans: ISBN 978 0 85847 578 6

Published by the Australian Academy of Science
GPO Box 783
Canberra ACT 2601
Telephone: 02 62019400

www.science.org.au

Click **here** for a full version of unit acknowledgements and sources or logon to www.sciencebydoing.edu.au.

Last modified: March 2019