Materials to repair teeth

Science content

Properties of dental materials, amalgam, polymer composite.

Science curriculum links
AT 1 Exploration of science
AT 6 Types and uses of materials

Syllabus links
- GCSE Science, Biology, Chemistry

Cross-curricular themes
- Health Education

Lesson time
1 hour
and homework

Links with other SATIS materials
401 Fluoridation of Water Supplies
606 Tristan da Cunha Dental Surveys
1106 Tin Cans

NERIS
Search on
DENTAL HYGIENE
and UPPER SECONDARY
Additional search term:
DENTAL SYSTEM

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SUMMARY

The unit is about the properties of materials in the context of dentistry.

STUDENT ACTIVITIES

- ☐ **Part A** Information, data collection and interpretation: filling a tooth, materials for fillings, frequency of filled teeth.
- ☐ **Part B** Information and questions about amalgam fillings.
- ☐ **Part C** Information and questions about polymer composite fillings.
- ☐ Role-play situations.
- ☐ Multiple-choice quiz about looking after teeth.

AIMS

- ☐ To complement work on metals, plastics, materials and teeth
- ☐ To provide opportunities for students to practise a variety of data handling techniques including data collection, recording, interpreting and predicting
- ☐ To show that properties of materials determine their successful use and that these properties can be altered

USING AND ADAPTING THE UNIT

- ☐ It is not intended that students should do all the activities. The unit may be used in a variety of ways, either as an exercise on materials (omitting the activities and quiz) or as a stimulus to data collection and interpretation.
- ☐ The quiz is a light-hearted activity and an opportunity to reconsider dental hygiene.
- ☐ The unit presents an opportunity for some assessment of data handling skills at various levels in **Attainment Target 1** such as: *record findings in tables, construct a simple pie chart, construct a simple bar chart or line graph, make written statements of the patterns derived from the data, record data in tables and translate it into appropriate graphical forms, use experience and knowledge to make predictions in new contexts.*
- ☐ Instructions for demonstrating the making of dental amalgam are included in the teaching notes overleaf.

Teaching notes

Part A – A dental check up

Activity A An analysis of the results may show up some interesting features. Students could be encouraged to write up the results in the form of an article for a newspaper or magazine.

Homework activity To increase the sample size it may be better to collect together the results for the whole class although this point may well emerge if students are made to evaluate their own results and compare their findings with others.

Part B – Repairing teeth using amalgam

Demonstration Making amalgam

A local dentist may be able to supply you with a sample of the powdered silver alloy. Most schools have mercury.

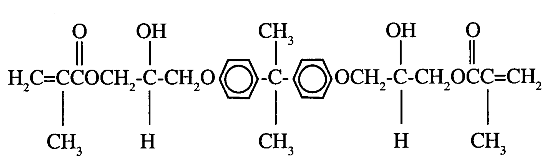
Mix roughly equal amounts of silver alloy with mercury using a pestle and mortar.

PRECAUTIONS: Remove any gold rings because mercury will amalgamate with gold very quickly. Mix over a large plastic tray in case of spillages of mercury. Any spillage must be completely cleaned up as prescribed for the use of mercury. Mercury vapour is poisonous. Only small quantities of amalgam are needed to demonstrate its putty-like nature when freshly mixed. Put amalgam under water until it is set before disposing of it.

Part C – Repairing teeth using polymers

This section deals with basic ideas about composite materials and polymers.

The chemical formula for Bis-GMA is:



Activity C – Role-play

The role-play scenes could be used as an alternative to answering questions Q1, Q6, Q7 and Q8.

Answers to the questions

Q1 *See figure 1.*

Q2 *Answers need to consider the taste, toxicity, strength and resistance to corrosion. Plasticine would be too soft (low compressive strength); cellulose filler (e.g. Polyfilla) has little resistance to abrasion; aluminium is difficult to work and is attacked by acids; gold is unreactive and used – but expensive.*

Q3 *Copper, tin, zinc, silver and mercury. Silver 64 %, tin 28 % approximately.*

Q4 *(a) bigger; (b) filling shrinks; (c) expands.*

Q5 *About 6 hours until graph B levels off. (Note that the horizontal scale to both graphs is logarithmic.)*

Q6 *Resistance to compression and abrasion, (also reflects light).*

Q7 *Blue light provides the energy to start polymerisation. (It initiates the formation of free radicals. The original polymer filling materials required ultraviolet light. Bis-GMA is activated by light of wavelength 470 nm which is not harmful at normal intensities.)*

Q8 *Polymer – appearance white to match teeth, long lasting, causes problems of shrinkage when used for large cavities in filling back teeth. (They can be overcome – a new technique is to make and cure the filling, allowing it to shrink, and then cement it into the tooth.)*

Q9 *Easily stored, easy to work, structural stability, resistance to corrosion by foods, high compressive strength, resistance to abrasion, no change in volume on setting, low thermal conductivity, appearance to match teeth, etc.*

Quiz

The quiz on page 7 may be printed separately. It may be used at the beginning or end of the unit. It is intended to remind students how to look after their teeth and may be set for homework.

Answers to quiz

1 **A**, 2 **C**, 3 **B**, 4 **C**, 5 **B**,
6 **C**, 7 **C**, 8 **A**, 9 **C**, 10 **A**.

Acknowledgements

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Materials to repair teeth

Part A A dental check-up

Most people don't enjoy going to the dentist. A check-up may find decay and the tooth will need to be repaired with a filling.

The unit is divided into four parts.

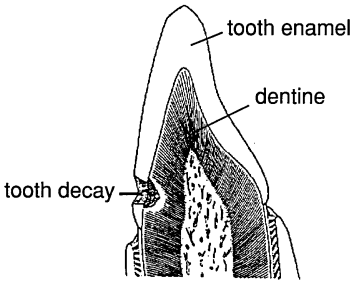
Part A: Introduction to dental fillings and materials; a data collection survey.

Part B: Repairing teeth using amalgam – information and questions.

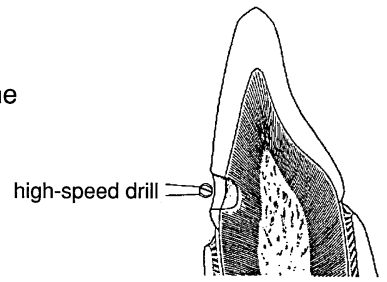
Part C: Repairing teeth using the polymer composite Bis-GMA – information, questions and scenes for role-play.

Quiz: A light hearted revision of dental hygiene.

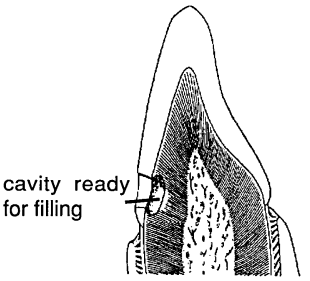
Figure 1 The stages in repairing a tooth



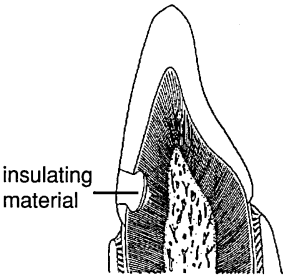
1 The tooth decay has eaten through the enamel and into the dentine. Once decay has reached the dentine it spreads rapidly and must be treated.



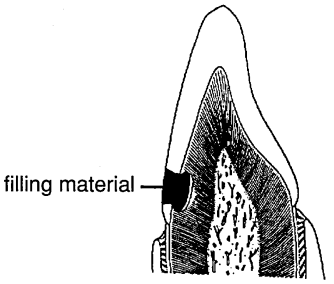
2 The dentist removes the decayed part of the tooth with a high-speed drill. The drill is water-cooled to stop overheating.



3 The bottom of the cavity is made bigger than the opening to anchor the filling and stop it from falling out.



4 If the cavity is deep, the dentist will line it with an insulating material to seal off the dentine.



5 The dentist fills the cavity with amalgam or polymer filling material.

Dentists use a wide range of materials:

- **metals** and **alloys** *for fillings and dentures,*
- **polymers** *for fillings and denture bases,*
- **polymer composite** materials *for fillings,*
- **elastomers** *for dental impressions,*
- **inorganic salts** *for dental cements,*
- **ceramics** *for porcelain crowns.*

Q1 *Imagine you are a dentist repairing the tooth shown in the diagrams. What would you say to a child aged ten to describe what you are doing?*

Filling materials have to be able to resist attack by acid in food and drink. They have to bear the enormous forces caused by chewing and withstand quick changes in temperature – from hot soup to ice-cream.

This unit considers two of the most common materials used by dentists to repair teeth – dental amalgam which looks silvery and a polymer composite which looks white.

Q2 *Here is a list of materials. How would they meet the needs of filling teeth – what would be their advantages and disadvantages?*

Plasticine, cellulose filler (used for cracks in walls), aluminium, gold

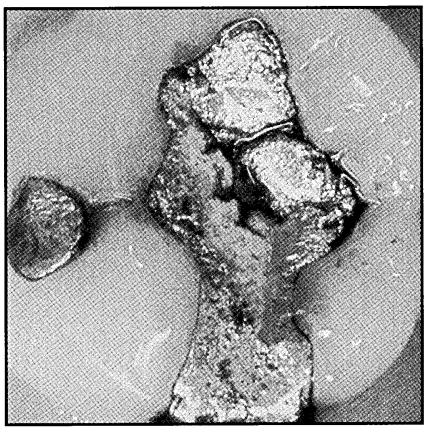


Figure 2 A tooth with an amalgam filling

Homework activity

Ask your family and friends if they are willing to take part in a survey of dental of fillings and age (Be tactful!).

Display your results in a suitable way.

Do the results show a link between number of fillings and a person's age?

Are there any other patterns in your results? If so, try to explain them.

Activity A – Data collection and interpretation

1 Use a mirror to look at your own teeth. Do you have any *amalgam* fillings? Note down how many.

2 Collect together the results for the number of fillings for each person in your class. Draw a table showing the results of the survey.

Number of amalgam fillings	0	1	2	3	4	5	6	7	8	9
Number of people										

3 Draw a bar chart or line graph to show the frequency of fillings in the class.

4 What is the most common number of fillings a person in your class has?

5 If you had surveyed the following groups of people, would you expect the results to be different?

Group 1 – another group of pupils but aged 11 or 12;

Group 2 – a group of adults aged between 35 and 45;

Group 3 – a group of pupils of similar age to yourself but the survey was carried out in 1960.

Give reasons for your predictions.

Part B – Repairing teeth using amalgam

What metals make up amalgam?

An amalgam is a mixture of solid metals with a liquid metal – usually mercury.

Dental amalgam has been used as a material to fill teeth for over 100 years. Amalgam fillings are made from *five* metals mixed in mercury. The dentist buys these metals as an alloy powder. Its composition is shown in the pie chart.

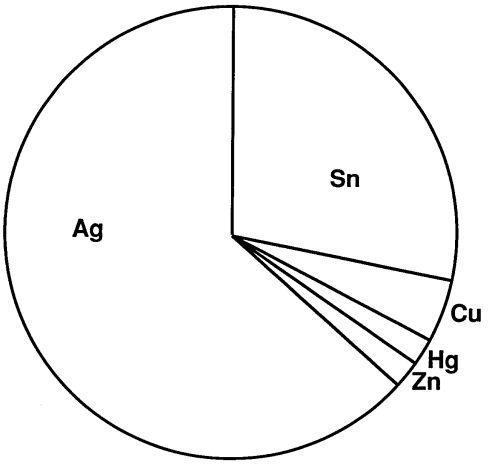


Figure 3 Composition by mass of alloy powder before being mixed with mercury to make amalgam

Each metal plays an important part in making the mixture suitable for filling teeth. For example, copper helps to make the mixture strong. Zinc protects the other metals from oxidation when the alloy powder is being manufactured. Being more reactive it combines with oxygen before the other metals can.

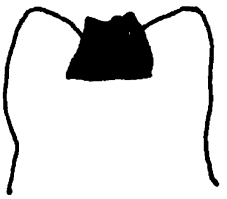
> ***Q3*** *Look at the pie chart. Name the five metals used to make the alloy powder. Estimate and write down the percentage of the two metals which make up the bulk of the alloy powder.*

How is the amalgam made?

The dentist removes the decayed part of the tooth. The amalgam is made by mixing the alloy powder with mercury. Mercury has to be handled with great care because it is a poisonous liquid.

Fresh amalgam is soft like Plasticine and easily pushed into holes in teeth. In time, it sets rock hard.

Too much shrinkage



Too much expansion

Figure 4 The effect of shrinkage and expansion on how a filling fits the cavity

On mixing the particles of alloy powder start to dissolve in the mercury to form a solution. At the plastic stage, the amalgam consists of untouched 'cores' of alloy surrounded by mercury. Gradually crystals form. The mercury is tightly held within the crystals and is therefore not harmful.

Materials change in volume as they 'set'. Ideally, material for fillings should not shrink too much. If they do, the filling may come away from the side of the hole and allow bacteria and food to get in the gap causing more decay. If on the other hand the filling expands too much, bits of filling may get broken off.

The two graphs labelled A and B show what happens to amalgam fillings over a period of time.

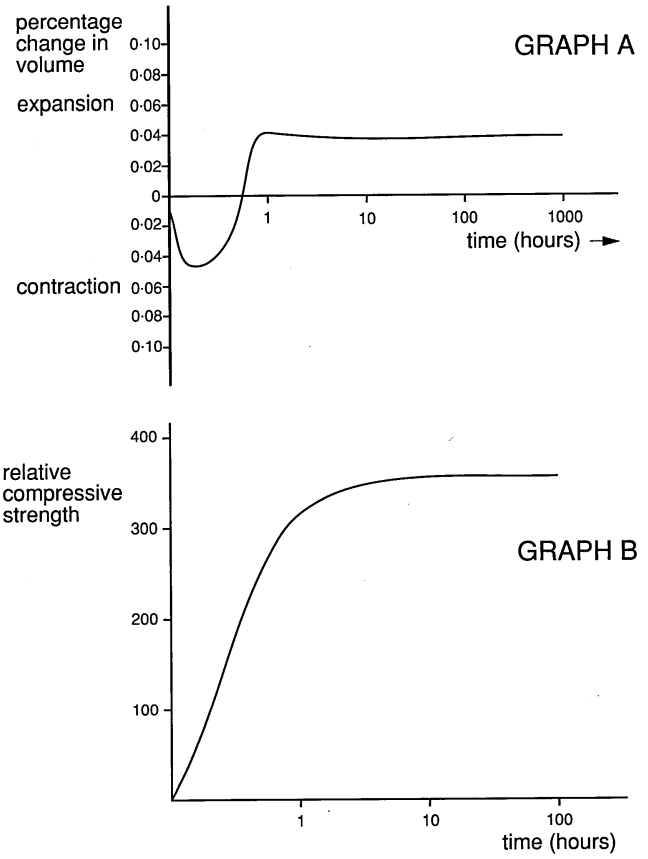


Figure 5 The changes in volume and compressive strength as an amalgam filling sets

Q4 *Study graph A.*
(a) Is the filling bigger, smaller or the same size after 1000 hours?
(b) What happens to the filling during the first 20 minutes or so?
(c) What happens after that?

Q5 *Study graph B. The patient may ask 'how long should I wait before I eat normally?' What would be your answer if you were a dentist?*

Dental amalgam is unreactive to attack by acid foods. When set, it has a compressive strength high enough to withstand the forces of chewing. If the amalgam is mixed correctly and the tooth filled carefully, an amalgam filling should last for several years.

However, there are problems with dental amalgam as a material to fill teeth. Like all metals, dental amalgam is a good conductor of heat. A large filling needs to be lined, otherwise the tooth is sensitive to hot and cold. Dental amalgam has a poor tensile strength – but on the whole this does not matter. The main problem for the patient is colour. For this reason dentists repair front teeth with a polymer material.

Part C – Repairing teeth using polymers

A polymer is a material with very long molecules. Plastics such as polythene, acrylic, nylon and polystyrene are all examples of polymers.

To repair teeth dentists need a very strong and rigid polymer which can withstand the harsh treatment that teeth get. The polymers used by dentists today were introduced in 1969. They harden only when the dentist shines blue light onto the filling.

What is the filling material made of?

The filling material is a **composite material**, that is, it is made of two parts – a chemical called **Bis-GMA** and very finely ground glass. At the start Bis-GMA is a thick colourless liquid. The mixture of Bis-GMA and ground glass is a fairly flexible paste and easily moulded into shape to fit the hole in the tooth.

What happens when blue light is shone onto the mixture?

Bis-GMA consists of fairly short molecules. The molecules cannot react with the ends of other Bis-GMA molecules without the help of a little more energy. The dentist's blue light supplies energy of exactly the right frequency to start the chemical reaction.

Small Bis-GMA molecules (called the monomer) link together to form the polymer. This type of chemical reaction is called **polymerisation**. A very rigid three-dimensional structure forms, trapping the particles of ground glass. The material sets hard and looks white.

The diagrams in figure 7 show what happens.

Q6 *Suggest what properties the finely ground glass adds to the composite material.*

Q7 *Why does the dentist shine blue light on the filling?*

After drilling out the cavity for a polymer filling, the dentist uses a weak acid to dissolve the enamel around the edges. This leaves it with a microscopically pitted surface. The dentist applies the Bis-GMA monomer first so that it can flow into these pits and then applies the paste of the composite material. When it is cured, the filling bonds with the tooth enamel.

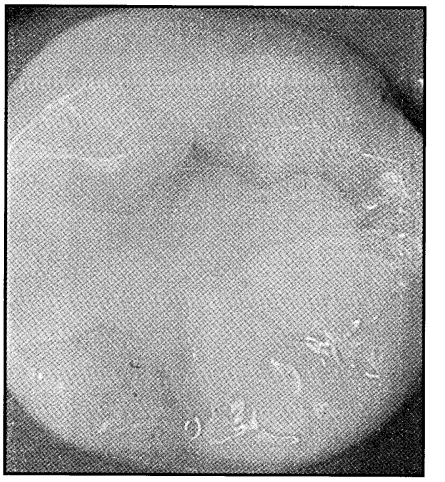
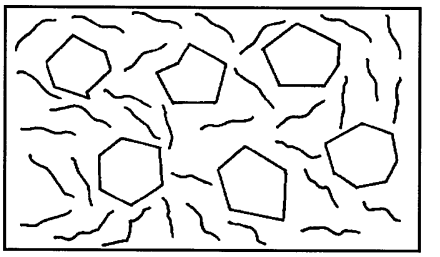
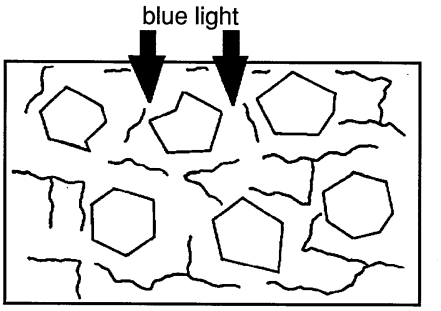


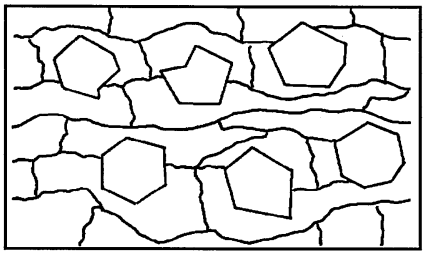
Figure 6 A tooth filled with polymer filling



1 Very fine glass particles surrounded by short molecules of Bis-GMA.



2 Blue light starts the chemical reaction between the Bis-GMA molecules. The short molecules link together to form a polymer.



3 The 3-D structure of the giant molecule makes it very hard and rigid – an ideal material for fillings.

Figure 7 How the dentist's blue light sets a polymer filling

What are the properties of polymer fillings?

Most importantly for the patient, the filling looks good and does not become discoloured. Polymer fillings are strong, resistant to acids and to changes in temperature. Unfortunately they shrink slightly on setting so that large cavities in back molar teeth have to be built up layer by layer, curing each layer as it is added with blue light.

Fillings in teeth do not last for ever. Changes in temperature mean that fillings expand and contract very slightly. They may work loose, chip or wear away. Eventually they need replacing.

Evidence suggests that polymer fillings last as well as amalgam ones. They may in fact be better, since they bond to the tooth itself. However, polymer fillings have not been in use long enough to know for sure.

New materials for filling teeth are expensive. Much work was done on their development. Research continues to discover stronger and better materials to repair teeth.

Q8 *Dentists often use polymer to fill front teeth, but amalgam to fill back teeth. Why?*

Q9 *Look back through the unit. Make a list of the properties that an ideal material for repairing teeth should have.*

Activity C – Scenes for role-play

What would you do in the following situations? Think up some ideas before you act out the scene.

Scene one

A: You are a teenager going for a dental check-up. You need a tooth filled for the first time.

B: You are the dentist. Explain to your patient who has never had a tooth filled before what you will be doing.

Scene two

A: You are a teenager who has not been for a dental check-up for three years.

B: You are a dentist. You find several decayed teeth.

Answers to questions are given in the *Teachers' Notes.*

Quiz

So you think you know how to look after your teeth?

Here are ten quick questions about keeping your teeth and gums healthy. Choose an answer. When you have finished, check to see how well you did. Your teacher has the answers.

1 Which snack is worst for your teeth?

A toffee **B** celery **C** peanuts

2 Which drink is worst for your teeth?

A water **B** milk **C** lemonade

3 Which is most likely to cause tooth decay?

A salt **B** sugar **C** vitamin C

4 When should you clean your teeth ?

A once a day **B** twice a day **C** after every meal

5 When should you visit the dentist for a check-up?

A once a year **B** every 6 months **C** when you get toothache

6 Fluoride is added to toothpaste and drinking water to

A kill bacteria **B** remove plaque **C** make tooth enamel stronger

7 Brushing your teeth will not remove any

A bacteria **B** plaque **C** tartar

8 Which type of new toothbrush is best for cleaning your teeth?

A small head / soft bristles
B large head / hard bristles
C small head / hard bristles

9 Tooth decay is caused by

A bacteria eating away the tooth
B food particles getting stuck in between teeth
C bacteria breaking down food making an acid which attacks teeth

10 How often should you use dental floss?

A three times a week
B once a week
C when food gets stuck between your teeth

For each correct answer you score 1 mark. If you get the answer wrong you score 0.

Your score		
	0–3	I wouldn't be a tooth in your mouth!
	4–6	Your teeth would feel happier if you knew a bit more.
	7–10	Well done!