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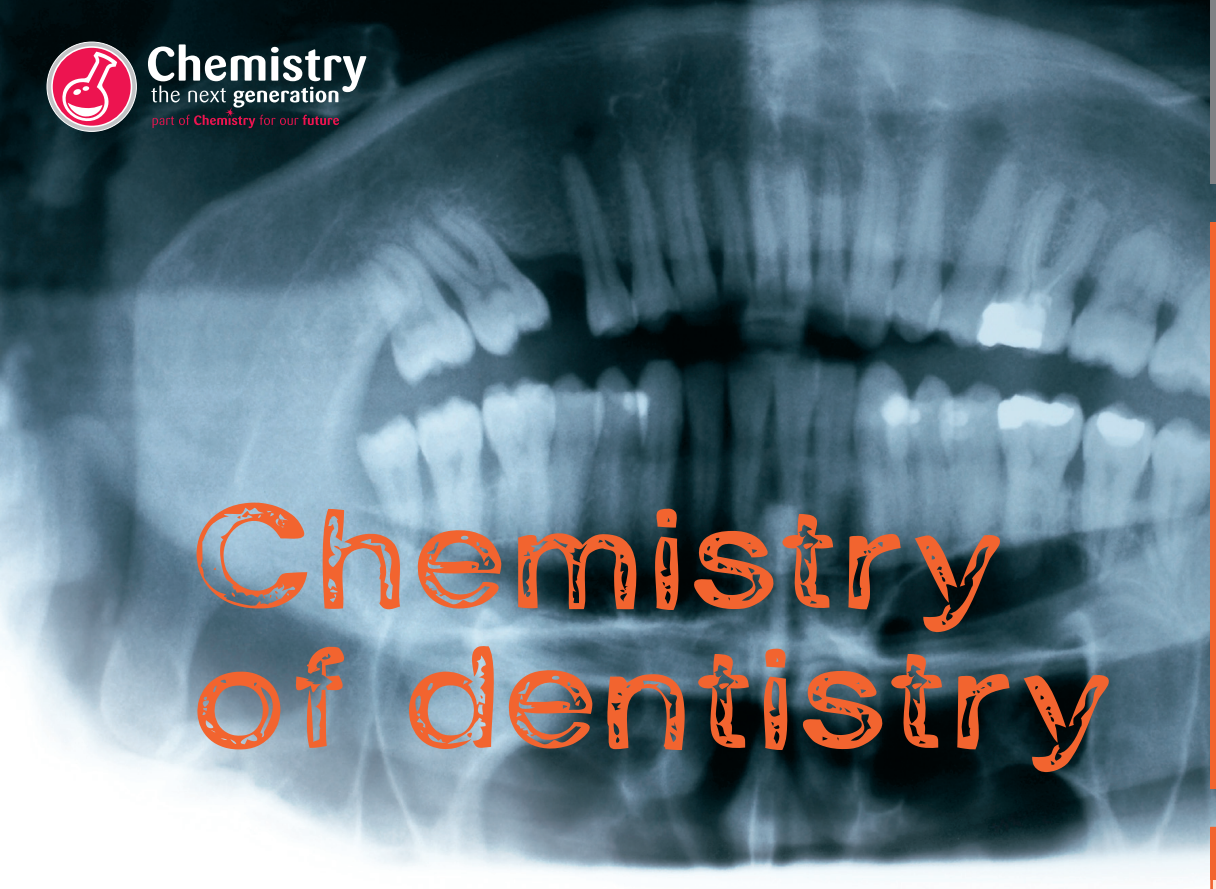
12
ACTIVITY



Chemistry of dentistry

age 16-18

4 1/4 HRS

30 STUDENTS

30 STUDENTS PER GROUP

6 SUPERVISORS

£1500

background

The event introduces students to the role of chemistry in dentistry by discussing tooth decay. Students should have a knowledge of chemistry up to GCSE but don't have to have a background in biology. Tooth decay is a disease that affects most people in the world and occurs when bacteria in the mouth process sugars. This produces lactic acid, a substance that attacks the mineral component of a tooth, forming soluble products that wash away leaving the tooth weakened. Tooth decay can be treated by using fluoride-containing toothpastes. Fluoride ions are able to become incorporated into the tooth mineral, making the mineral much more resistant to acid attack. Fluoride ions also reduce the solvating ability of saliva. Both effects stop tooth decay.

pre-planning required

weeks before
Order materials, print instruction sheets for practicals.

days before
Set out equipment in laboratory and organise the lecture room.

facilities required

- A computer and digital projector for the opening Power Point presentation
- A teaching laboratory
- Equipment for disposing of biologically hazardous waste ie used impression material that is contaminated with saliva

materials required

- silicone impression putty
- glass-ionomer dental cement or Plaster of Paris
- solutions of lactic acid
- solutions of KF, Potassium Fluoride
- toothpaste
- two ion-selective electrodes(2)
- pH meter

Suggested timings for the day

10.45	Arrival and welcome, plus refreshments
11.15	Opening presentation, with questions
12.00	**Practical session 1**
12.30	Lunch
13.15	**Practical session 2**
13.45	Prepare report on first experiment
14.15	Presenting results and discussion
14.45	Closing remarks and feedback forms
15.00	Finish

SAFETY
A risk assessment must be done for this activity.

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Description of the activity

The event begins with a 40 minute presentation explaining how dental decay is a disease caused by chemical imbalance. It goes on to describe the role of fluoride in lessening the effects of decay and the chemically sophisticated materials used to repair damaged teeth, particularly tooth-coloured plastic-based materials.

There are two practical sessions.
First, the students take an impression of one of their own teeth, using clinical impression material and then fabricate a model tooth using an appropriate cement.

After lunch, in the second practical session, the students do one of four experiments.

1. Determining the pH of lactic acid solutions to estimate the concentration required to cause active decay (pH 4.5).
2. Determining the fluoride release from toothpaste using a F-ion selective electrode.
3. Measuring the uptake of fluoride by hydroxyapatite (the mineral phase in teeth), again using a F-ion selective electrode.
4. Studying the relationship between depth of cure and length of light exposure in light-cured tooth-coloured filling material.

This resource is based on an activity run by Dr John Nicholson, University of Greenwich

Practical session 1

Preparing a model tooth

Dentists need to be able to make artificial teeth that are similar to the real teeth they replace. To do this they use impression materials usually a self-curing rubber – and use the resulting moulds to make artificial teeth, usually from ceramics. This activity uses silicone rubber and self-hardening cement to make the model tooth.

1. Take equal – but small – amounts of each colour of the two-paste impression material and mix them with your fingers until they are fully mixed, and allow the putty to set slightly. This takes around 2-3 minutes.

2. Place the semi-set mould over one of your incisors and hold it there for around 5 minutes until it sets.

3. Weigh 6 g of cement powder in a measuring cup on a balance.
   Add 2 cm^3 of water from a pipette.
   Use a stirrer to mix the cement in the cup until it becomes a paste.

4. Fill your tooth impression with the mixed cement and allow it to harden – this takes around 10 minutes.

5. Remove the model tooth from the mould.

6. Inspect your model tooth carefully.
   Is it a good representation of your tooth in terms of
   - shape
   - colour
   - markings?

SAFETY

The moulds are biohazards as they are contaminated with saliva and they must be disposed of in the bags marked biohazard.

Practical session 2

The pH of lactic acid solutions

Lactic acid is the main acid produced by bacteria in our mouths. These bacteria form a biofilm on the surface our teeth known as plaque. They form the lactic acid by converting glucose as part of their metabolic processes.

Lactic acid at pH 4.5 causes tooth decay and in this experiment you measure the pH of a series of lactic acid solutions and use these results to estimate the concentration of lactic acid that causes decay.

You are given four lactic acid solutions of different concentrations – 1.0 mol dm^{-3}, 0.1 mol dm^{-3}, 0.01 mol dm^{-3}, 0.001 mol dm^{-3}, and a pH meter.

1. Check that the pH meter is properly calibrated by using the pH 4 and pH 7 solutions provided.

2. Pour small amounts of each of the lactic acid solutions into beakers and check the pH of each solution.

3. Record your results.

Concentration of lactic acid solution	pH
1.0 mol dm^{-3}	
0.1 mol dm^{-3}	
0.01 mol dm^{-3}	
0.01 mol dm^{-3}	

4. Either by calculating or estimating from your results, suggest the approximate concentration of lactic acid that causes the pH (4.5) of active tooth decay. What can you conclude about the amount of glucose needed to cause tooth decay?

Measuring the release of fluoride ions (F^-) from toothpaste

How much fluoride is present when you clean your teeth? Toothpaste labels claim that 100% of the fluoride in the toothpaste is released within three minutes of brushing, but is it true? We can do some simple experiments to check whether this is likely.

1. Pour 25 cm^3 of deionised water into a screw-capped test-tube.
2. Squeeze approximately 10 cm^3 of toothpaste into a plastic cup and use a syringe to measure accurately 1 cm^3 of toothpaste.
3. Syringe the toothpaste into the screw-capped test-tube containing the deionised water and replace the cap securely.
4. Shake the toothpaste solution vigorously for at least 3 minutes.
5. Use an electrode to measure the fluoride concentration.
6. Record your results.

Quantity	Action	Value
Fluoride concentration (mg dm^{-3})	From meter reading	
Mass of fluoride released (mg)	= concentration x 25/1000	
Expected fluoride released (mg)	0.99 mg, 1.10 mg, 1.45 mg	

- Do your results agree with the expected value? If they don't why do you think this might be?
- How do you think this experiment could be improved or redesigned to better represent the release of fluoride ions during brushing?

Fluoride uptake by hydroxyapatite

Hydroxyapatite is the natural mineral phase of our teeth and bones and is a complex calcium phosphate mineral with extra hydroxyl groups (OH^-). When the OH^- groups in the upper layers of teeth and bone are replaced by F^- ions, the resulting mineral is much more resistant to acid attack than the original hydroxyapatite. The following experiment determines the rate of uptake of fluoride by synthetic hydroxyapatite powder as a model of the process that can occur in our mouths.

You are given a solution of 1000 ppm potassium fluoride (KF), a fluoride electrode and a meter.

1. Check that the meter corresponds to 1000 ppm for the solution.
2. Weigh 0.6 g of hydroxyapatite powder in a beaker. Add 5 cm^3 of 1000 ppm KF solution and note the time.
3. Using the meter, record the values at 2 minute intervals for 10 minutes.
4. Record the fluoride concentration values at the different time intervals.

Time intervals	Fluoride concentration
Two minutes	
Four minutes	
Six minutes	
Eight minutes	
Ten minutes	

- What happens to the fluoride concentration?
- What can you conclude about the rate of the process?
- How might the conditions in your mouth differ from those in the experiment?

Depth of cure of light-hardened composite resins

One on the most widely used tooth-coloured materials is 'composite resin', which is a plastic material consisting of monomers and fillers, including pigments. It is cured, ie hardened, using visible light.

You are given some composite resin and a dental care unit.

1. Fill the metal mould with composite resin.
2. Place a glass microscope slide over the end of the resin and expose to the cure light for an appropriate length of time – 10, 20, 30 and 40 seconds.
   The lamp runs for 20 seconds so must be moved away from the resin if necessary to make sure you use the correct cure time.
3. After exposure to the light, remove the specimen from the mould and use a spatula to scrape any resin from the far end of the mould. Measure the length of the cured specimen.
4. Record the depth of cure values.

Exposure time	Depth of cure
Ten seconds	
Twenty seconds	
Thirty seconds	
Forty seconds	

- What precautions do your results suggest are necessary when dentists use these materials on real patients?
- Why is the composite resin stored in a black tube?

At the end of the day the students present their results to share with the rest of the group.

NOTE

Although the light emits mainly visible light, it also emits a small amount of ultraviolet light. This damages the retina in your eye. The light must be used carefully and should always be viewed through the orange filter.