<u>Making a plastic from potato starch</u>

In this activity students make a **plastic** from potato starch and investigate the effect that adding a **'plasticiser'** has on the properties of the **polymer** that they make.

Extracting starch from potatoes

Potatoes (100 g)
Grater
Beakers (400 cm^3), 4
Large pestle and mortar

Access to:

Tea strainer
Distilled water

Making the plastic film

Beaker (250 cm^3)
Large watch glass
Bunsen burner
Heat resistant mat
Tripod
Gauze
Stirring rod
Petri dish or white tile
Universal indicator paper
Teat pipettes
Measuring cylinder (25 cm^3)
Measuring cylinder (10 cm^3)

Access to:

Balance (not essential, see note 1)
Potato starch - either extracted in the first part or 2.5 g bought potato starch (see note 2)

Food colouring
Propane-1,2,3-triol (glycerol)

Dilute hydrochloric acid, 0.1 mol dm^{-3} (**Low hazard** at this concentration)
Dilute sodium hydroxide, 0.1 mol dm^{-3} (**Irritant** at this concentration)

Technical notes

Dilute hydrochloric acid (**Low hazard** at concentration used) Refer to CLEAPSS Hazcard 47 and Recipe card 31
Dilute sodium hydroxide (**Irritant** at concentration used) Refer to CLEAPSS Hazcard 91 and Recipe card 65

1 If access to a balance is difficult get students to use a heaped spatula of starch rather than 2.5 g.

2 Even if students are extracting their own starch, it is worth having some commerical potato starch available in case they do not extract enough.

3 If a drying cabinet is available, it is useful for drying out the plastic films. It takes about 90 mins at 100 °C.

Procedure

HEALTH & SAFETY: Wear eye protection

Extracting the starch

a Grate about 100 g of potato. The potato does not need to be peeled, but it should be clean. Put the potato into the mortar.

b Add about 100 cm^3 of distilled water to the mortar, and grind the potato carefully.

c Pour the liquid off through the tea strainer into the beaker, leaving the potato behind in the mortar.

d Repeat steps **b** and **c** twice more.

d Leave the mixture to settle in the beaker for 5 mins.

e Decant the water from the beaker, leaving behind the white starch which should have settled in the bottom. Put about 100 cm^3 of distilled water in with the starch and stir gently. Leave to settle again and then decant the water, leaving the starch behind.

Making the plastic film

a Put 22 cm^3 of water into the beaker and add 4 g of the potato starch slurry from the previous step (or 25 cm^3 water and 2.5 g of commercial potato starch), 3 cm^3 of hydrochloric acid and 2 cm^3 of propane-1,2,3-triol.

b Put the watch glass on the beaker and heat the mixture using the Bunsen burner. Bring it carefully to the boil and then boil it gently for 15 mins. Do not boil it dry. If it looks like it might, stop heating.

c Dip the glass rod into the mixture and dot it onto the indicator paper to measure the pH. Add enough sodium hydroxide solution to neutralise the mixture, testing after each addition with indicator paper. You will probably need to add about the same amount as you did of acid at the beginning (3 cm^3).

d You can then add a drop of food colouring and mix thoroughly.

e Pour the mixture onto a labelled petri dish or white tile and push it around with the glass rod so that there is an even covering.

f Repeat the process, but leave out the propane-1,2,3-triol.

g Label the mixtures and leave them to dry out. It takes about one day on a radiator or sunny windowsill, or two days at room temperature. Alternatively, use a drying cabinet. It takes about 90 mins at 100 °C.

Teaching notes

This activity can be used simply as a practical to enhance the teaching of polymers or plastics. It can be used to introduce further work on biopolymers and bioplastics and/or it can be used as an example of the effects of plasticisers. A similar process is used in industry to extract starch, which is then used in a number of products including food and packaging.

If students extract their own potato starch then they can use that. It is a wet slurry rather than a dry powder so they need about 4 g with about 22 cm^3 water. If they do not have enough then they can add a bit of bought potato starch to the mix.

If access to a balance is difficult, then get students to use a heaped spatula of starch rather than 2.5 g.

If access to 10 cm^3 measuring cylinders is difficult, then get students to use four pipette squirts of hydrochloric acid and three squirts of propane-1,2,3-triol.

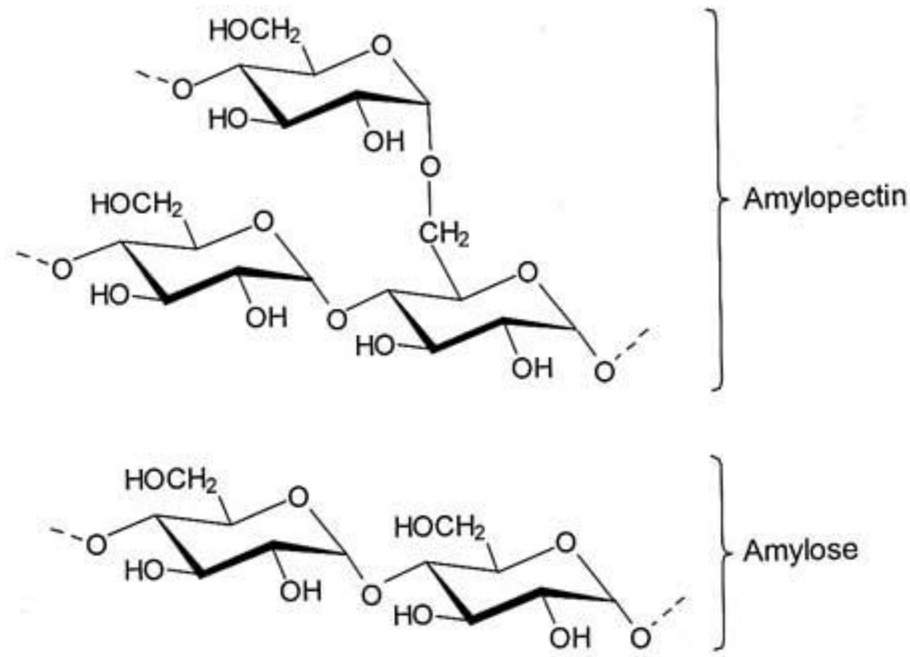
If you have a drying cabinet, the mixture should dry in about 90 mins at 100 °C.

Warn students not to let the mixture boil dry, or it ‘pops’ and has a tendency to jump out of the beaker. For this reason, students should wear eye protection at all stages.

While using food colouring is optional, it does enhance the product and the colour it gives makes the plastic film look more like plastic. Only one drop is needed or the film is too dark.

If students use too much water then their polymer won’t solidify and remains a liquid.

Starch is made of long chains of glucose molecules joined together. Strictly it contains two polymers: amylose which is straight-chained and amylopectin which is branched. When starch is dried from an aqueous solution it forms a film due to hydrogen bonding between the chains. However, the amylopectin inhibits the formation of the film. Reacting the starch with hydrochloric acid breaks down the amylopectin, forming more satisfactory film. This is the product that students make without propane-1,2,3-triol. The straight chains of the starch (amylose) can line up together and although this makes a good film, it is brittle because the chains are too good at lining up. Areas of the film can become crystalline, which causes the brittleness.



Section of a starch molecule (amylose and amylopectin)

Students should be able to see a difference in the two films that they make. The one without the propane-1,2,3-triol is far more brittle, the one with it shows more plastic properties.

Adding propane-1,2,3-triol makes a difference due to its hydroscopic (water attracting) properties. Water bound to the propane-1,2,3-triol gets in amongst the starch chains and stops the crystalline areas from forming, preventing the brittleness and resulting in more 'plastic' properties, thus acting as a plasticiser. This can be explained to students without mentioning water – just that the propane-1,2,3-triol acts as a plasticiser.