Alloys: modelling an alloy

This experiment enables students to experience how alloying can be used to change the properties of a metal. Plasticine is mixed with varying amounts of sand and the ductility of the sample is measured in a simple test. The plasticine is used to represent the main metal in an alloy, eg iron, and the sand represents an added substance, eg carbon in steel.

The practical is suitable for students of all abilities and can remain at the level of observation for the less able or act as a springboard to the explanation of the properties of alloys for the more able.

Equipment required

Per pair or group:

- 4 x 35 g samples of plasticine – one with no sand added, one with 2 g, one with 4 g and one with 6 g sand
- Magnifying glass.

Extension activity only:

- 35 g sample of plasticine with either 3 g or 5 g sand added (you need to know how much).

Samples

The samples can be prepared by a technician or by students so practical details are given on a separate sheet. Samples can be used several times so it is worth colour coding them for ease of identification (eg all samples containing 2 g sand are made using blue plasticine). For the experiment to give good results it is very important that the sand is mixed thoroughly and evenly with the plasticine. If samples are to be stored, wrap them in cling film or place them in plastic bags to prevent the plasticine from drying out.

Sand from a builders' merchants is the best as the particle sizes tend to be fairly uniform. Sand from a fire bucket usually has a wide range of particle sizes and is often dirty so is not recommended for use in this experiment. If students make their own samples, remove the one containing 6 g sand from them until later in the experiment.

If students carry out the extension activity, they will require a further 35 g plasticine lump with either 3 g or 5 g sand added for them in advance.

Notes

If the same plasticine samples are used repeatedly they will always snap in the same place. To solve this problem simply re-mould the plasticine for a couple of minutes until all the sand is evenly distributed again and the sample is warm.

The plasticine and sand could be further investigated and other factors such as temperature tested for their effect on the properties of the samples. Students often get the terms brittle, malleable or ductile and strong muddled up. It is worth ensuring at some stage during the lesson that they are happy with the use of these terms. A material that can be stretched or drawn into wires is ductile (malleable means that it can be moulded into shape when cold). If it does not stretch but snaps, then it is brittle. A material can be strong but brittle – and indeed many are. The opposite of ductile is brittle – not weak.

The sheet Alloys of iron – steels can be used after the Alloys: modelling an alloy practical activity. It may help students to understand the structure of metals and how they can be changed by alloying if you demonstrate this to them using polystyrene balls in a tray or a similar model.

Answers

Alloys: modelling an alloy

1. Ductile means that the material can be drawn into wires.
2. The iron is represented by the plasticine and the carbon by the sand.
3. The fracture surfaces are different sizes and there is a pattern. As more sand is added the fracture surface gets larger.
4. Before the plasticine broke it was stretched into a thinner shape. (This is called 'necking').
5. Before the plasticine broke, the force required to pull it apart at a steady rate reduced.
6. The fracture surfaces are rough with several small peaks. They contain more sand than the surface where the plasticine has simply been snapped.
7. As more sand is added to the plasticine it becomes less ductile and more brittle.
8. and 9. The lump with 6 g sand in it follows the trend of the other samples – it is less ductile, thins out less and has a larger fracture surface than the others. The difference between the sample with 4 g sand and that with 6 g is less marked than that between 0 g and 2 g or between 2 g and 4 g sand. (The results of this part of the experiment may vary depending on the type of sand used – there may be very little difference between the 4 g and 6 g samples.)

Modelling an alloy – making the model mixtures (extension activity)

You might expect students to decide to form a similar sized cylinder of plasticine and to perform the same test as for the other samples. By comparing the size of the fracture surface with their results from the previous experiment they should be able to deduce a possible range of values for the amount of sand in the sample.

Alloys: modelling an alloy

This experiment models what happens to a sample of metal when it is turned into an alloy by the addition of either another metal or carbon. The properties of alloys are different from the properties of the metals from which they are made. You are going to investigate how the ductility of plasticine changes when sand is added to it.

You will need

- 3 x 35 g lumps plasticine: one plain; one with 2 g sand added; one with 4 g sand
- Magnifying glass.

What to do

- Mould each of the plasticine samples for about a minute until it is at hand temperature.
- Shape each of the samples into a cylinder of about the same size and shape – 6 cm long and 1.5 cm in diameter.
- Hold the ends of the cylinder firmly and pull them apart slowly and steadily until the plasticine breaks. If your hands fly apart the test has failed and you will need to remould the cylinder and try again.
- Repeat for each specimen in turn, pulling with about the same force each time.
- Examine the fracture surface of the plasticine with a magnifying glass.

Questions

1. What does ‘ductile’ mean?

   _____

2. Steel is an alloy of iron that contains a small percentage of carbon. In the plasticine and sand model, what represents
   a. The iron

      _____

   b. The carbon

      _____

3. The diameter of each sample cylinder was about the same at the start. Are the fracture surfaces about the same size or is there a pattern in your results? If you can see a pattern, describe it.

   _____

   _____

   _____

4. What happened to the plasticine before it broke?

   _____

   _____

   _____

5. What happened to the force required to pull the ends apart at a steady rate before the plasticine broke?

6. Describe what the fracture surfaces look like. Snap off a piece of plasticine at the other end of the cylinder and compare the snapped surface to the fracture surface where the cylinder broke in the middle. Are they different? If so, how?

7. How do the properties of the plasticine change as sand is added to it?

8. Predict what you think you would happen if you used a 35 g lump of plasticine with 6g sand added and performed the same test. Write a prediction and draw a diagram.

Collect a plasticine sample with 6 g sand added and carry out the test.

9. Describe the results of your test. Do they agree with your prediction or are they different somehow? Comment on your results.

Extension activity

Collect a 'mystery' 35 g sample of plasticine which contains an unknown quantity of sand. Plan and carry out an experiment to find out how much sand is in the sample. Write down what you did and what you found out.

Modelling an alloy – making the model mixtures

You will need

- 4 x 35 g different coloured lumps of plasticine
- Sand
- Rough paper
- Access to a balance.

What to do

- Weigh out 2 g sand onto a piece of rough paper.
- Take one of the plasticine lumps and mould it until it is warm and malleable. Work it into a flat shape about 0.5 cm thick.
- Sprinkle the sand onto the plasticine and roll it up. Working over the rough paper, mould and work the plasticine, adding in any sand which falls out, until the sand is evenly distributed.
- Repeat with 4 g and 6 g sand in new samples of plasticine.