

# Engineering colour

Packaging engineers have to work out the best way to package their product. Packaging keeps the product in good condition, and prevents damage while it's taken to the shops. Often, the packaging has to look good too. Colour is very important. Designers decide on the style and colours they want. Then it's up to packaging engineers to make sure that the right materials and dyes are used.

Imagine you're a packaging engineer for a chocolate-making company. The company has an unusual request. It wants to make special gift packs – a selection of wrapped sweets and chocolates in re-useable, decorative fabric bags. The bag has to display the company logo.

It's your job to suggest which fabrics and types of dye they should use, to make sure the logo shows up clearly.



## your task

You're going to compare how well different types of dye can colour different types of fabric. You will then test the quality of each dye by seeing what happens when it is washed with detergent at different temperatures.

## what you will need

- multi-fibre strips, dyed with different types of dye
- 250 cm<sup>3</sup> beaker
- Bunsen burner
- tripod
- gauze
- heat-resistant mat
- 110 °C thermometer
- washing powder
- stirring rod
- tweezers

## safety

Take care when using a Bunsen burner.

## what you need to do

### Part 1: Dye observations

Your teacher will give you a multi-fibre strip. These are used by the colour industry to test dyes. They're made of six fabrics – acetate, cotton, nylon, polyester, acrylic and wool. When the strip is dyed, some fabrics react with the dye better than others. The better the reaction, the deeper the colour produced.

1. Look at an undyed strip and make sure you know which fabric is which.
2. Have a look at the strip and make a note of:
  - the name of the dye
  - the colour of the dye
  - the type of dye (natural or synthetic)
  - how well each fabric has 'taken up' the dye (for example, is the colour deeper or paler on some fabrics?)
3. Write your observations in a table like this.

dye			observation					
name	colour	type	acetate	cotton	nylon	polyester	acrylic	wool

4. Swap your multi-fibre strip with someone else in the class. Add to the table. Keep swapping until you have observations for six different dyes.

### Part 2: Washing the fabric

1. Collect three pieces of fabric dyed with the same dye. Record details of the fabric and dye in a table like the one on the next page.
2. Pour 200 cm<sup>3</sup> of water into the beaker. Heat the water gently until it reaches 20 °C.
3. Add 2 cm<sup>3</sup> of washing powder. Stir until the powder has dissolved.
4. Turn the Bunsen flame down low, to keep the water at 20 °C.
5. Add one strip of dyed fabric. Stir constantly for 5 minutes. (Remove the Bunsen if the temperature rises. Heat again if it cools.)
6. Use tweezers to remove the fabric and place it on a heat-resistant mat to cool.
7. Look at the colour of the fabric and the washing water. Record your observations in the table. How much of the dye, if any, has washed out of the fabric?
8. Repeat the experiment using a second piece of fabric, but heat the water to 40 °C.
9. Repeat the experiment with the last piece of fabric, but heat the water to 60 °C.

## results

type of fabric:		name of dye:	
colour of dye:		type of dye (natural or synthetic):	
wash temperature	observations		
20 °C			
40 °C			
60 °C			

Compare your results with those for:

- the same fabric as yours, but with a different dye
- other types of fabric dyed with the same dye as yours.

Write a report stating which fabric and which type of dye you recommend using, to make sure the logo is clearly displayed on the bags. Give your reasons.

## questions

- Use your results to answer these questions.
  - ~ In general, which type of dye (natural or synthetic) gives deeper colours?
  - ~ Which fabrics appear to be more difficult to dye?
  - ~ How does the wash temperature affect the dyes?
- What do we mean by the 'take up' of a dye?
- Some fabrics take up a particular dye better than other fabrics do. Also, any particular fabric takes up some dyes better than other dyes. What causes these differences in take up?
- Suggest why dyes wash out of some fabrics more easily than others.
- We describe some dyes as 'fast', but this is nothing to do with the speed of dyeing. Bearing in mind your experiments, what do you think a 'fast' dye is?

## extension

- Try dyeing various fabrics with home-made natural dyes extracted from fruit and vegetables.
- Leave strips of fabric in the sun to see how sunlight affects them.
- Investigate the effects of friction by rubbing the fabrics on different surfaces.

## engineers

- There are four engineers shown on the poster. What other engineers do you think might be needed to help make chocolate products and other sweets?
- As well as helping to make chocolate products, where else might you find a packaging engineer? Try to think of at least three areas of work.

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## Curriculum links

England and Wales (Key Stage 3 Science Programme of Study)	
key concepts	1.1b, 1.2a, 1.3a, 1.4a
key processes	2.1a-c
range and content	3.2c
curriculum opportunities	4a, c and k
Northern Ireland (Science Statutory Requirements)	
knowledge, understanding and skills	develop: enquiry skills; critical thinking; practical skills research information learn about: properties and uses of materials
objective 1 – develop as individuals	mutual understanding: team work
objective 3 – as contributors to the economy/environment	identify skills used in: the textile industry (design and dyeing) investigate the science behind: textile dyeing sustainable development: use of natural dyes
Scotland (SQA Science Outcomes)	
third level	SCN 328Z, 329Z

## Introducing the activity

This activity introduces pupils to the different types of dye – natural and synthetic – and how well different fabrics take up the dyes. It links to the packaging engineer because the materials used to package chocolate (or any other product) must be colour-printed or dyed. It is the job of packaging engineers to select and implement suitable colouring processes. They have to work closely with graphic designers to make sure the packaging is correctly branded and displays any necessary information, such as names, logos, and ingredients.

Before the practical, discuss the difference between paints (colours coated onto the surface) and dyes (colours that soak into the material). Pupils also need to understand that the term 'take up' means how well the fabric absorbs the dye, which determines how strongly coloured the material becomes.

Make sure they also appreciate that the multi-fibre strips are woven from six different types of fibre (named at the start of 'what you need to do'), all dyed at the same time in the same way. The differences in appearance are due only to differences in dye take up.

Do not discuss colour 'fastness' at this stage, since pupils are asked to think about this for themselves in the questions.

## The practical activity

For the first part of the activity (observation), pupils should swap their multi-fibre strips with one another until they have seen, and recorded observations of, six different dyes. You could, of course, choose to use more or fewer dyes, depending on time and availability. The range should cover both natural and synthetic dyes.

For the washing test, each group will need three strips of the same fabric dyed with the same dye. Each group should use a different combination of fabric and dye. For this part of the investigation, cut up the multi-fibre strips used in the first part.

## Preparing dyes

Dyes need to be prepared in advance. (This could be a student activity in itself, if you wish.)

**To make natural dyes:** boil about 30 g of the dyestuff with a tablespoon of salt in 250 cm<sup>3</sup> water for 30 to 60 minutes, then strain.

**Examples of natural dyestuffs include:** tea, coffee, blackberries (fresh is best, though frozen or tinned should work), daffodil heads (soak overnight before boiling), onion skins, avocado skins (soak overnight before boiling), or turmeric (only use about 5 g of powder). You could experiment with other leaves, flowers and fruits.

**To dye fabrics with natural dye:** simmer in the dye for approximately 45 to 60 minutes.

**Synthetic dyes** for fabrics are available from shops or on-line. Your CDT department may have examples. However, the active dyestuff is not normally named. To ensure that your samples illustrate differential dye take-up by different fabrics, use different classes of dye in contrasting colours, such as Acid Blue, Disperse Yellow and Direct Red. These are available from laboratory suppliers, or dye specialists such as Town End ([www.dyes.co.uk](http://www.dyes.co.uk)) or ELS ([www.eurolabsupplies.co.uk](http://www.eurolabsupplies.co.uk))

**To dye fabrics with synthetic dye:** follow instructions on packet.

You could also try synthetic and natural food colourings, available from supermarkets. Some experimentation will be needed to determine suitable dilutions for dyeing fabrics. Adding salt may assist dye uptake.

## Matching dyes to fabric types

After the practical, get the pupils to discuss their observations. They should have noticed that which fabric had taken up most colour depends on which dye was used. Each dye works best with different fabrics. For instance:

- Acid Blue is taken up most strongly by wool and nylon
- Direct Red [IRRITANT SOLID; SOLUTION LOW HAZARD] works best with cotton
- Disperse Yellow [IRRITANT SOLID; SOLUTION LOW HAZARD] dyes acetate well, but Acid Blue and Direct Red do not.

For successful dyeing, therefore, the type of dye must be matched with the type of fabric.

Explain that dyeing is not just a matter of soaking up a coloured liquid. Dyeing involves a chemical reaction between the fibres and the dye. This reaction attaches the coloured dye to the fabric.

A simple example: Pupils may know that acids react with bases. Wool and nylon are bases. (More correctly, they contain basic  $-NH_2$  groups.) They therefore react well with acid dyes.

The pupils should also notice differences between dyes during washing, and that this also varies with the dyes and fabric. Ask whether their results show any link between how well a fabric takes up a dye and how easily the dye washes out of the fabric. They should find the opposite – dyes that are easily taken up wash out less easily, since they have reacted with the fibres and become firmly attached.

Dyes that are less firmly attached wash out more easily during a hotter wash, because solubility increases with temperature.

The worksheet asks pupils what they think a 'fast' dye is. Discuss their suggestions, and ensure that they understand that the term refers to a dye that is held fast (tightly) onto the fibres. Dispel any ideas of speed.

The pupils should compare results for various fabric-dye combinations. The worksheet also asks them to choose the most suitable fabrics and dyes for the chocolate gift pack. They should, of course, choose a combination with good dye uptake, and good colour fastness.

Other types of dye-fabric interactions are more complex, and not needed at this stage. Teachers who are interested can find details at:

The Essential Chemical Industry,  
 Chemical Industry Education Centre,  
 University of York, 1999 pages 140-143

<http://www.practicalchemistry.org/experiments/dyeing-three-colours-from-the-same-dye-bath,204,EX.html>

<http://www.chemistry-videos.org.uk/chem%20clips/CD7%20Dyes/Fibre%20dyes.html> (but contains errors)

## Equipment

(Per group)

- multi-fibre strips\*, dyed with different types of dye
- 250 cm<sup>3</sup> beaker
- Bunsen burner
- tripod
- gauze
- heat-resistant mat
- 110 °C thermometer
- washing powder
- stirring rod
- tweezers

\*multi-fibre strips are available from the Society of Dyers and Colourists, PO Box 244, Perkin House, 82 Grattan Road, Bradford BD1 2JB. Tel: 01274 725138. Fax 01274 392888. Web: [www.sdc.org.uk](http://www.sdc.org.uk)

See *Preparing dyes*, above, for suggested dye suppliers.

## Possible extension activities

- There is a cross-curricular opportunity here with design and technology. Students could design the fabric bags before deciding on suitable materials to make them from. They could also design a company logo and chocolate wrappers.
- They could investigate other effects on dyed materials, such as sunlight and friction.
- This may also be a suitable opportunity to investigate inks using chromatography.