Colour

Student Notes

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Activity 1: An introduction to colour

Chromatography

1. Choose a stencil pattern and colour-in the dots using a selection of colours, or design your own using a series of dots.
2. Rest the circle of filter paper on the bowl.
3. Dip your finger in the cup of cold tap water to get a drop on the end and let it fall onto one of the coloured dots. Repeat this for all the dots.
4. Watch what happens to the colours and describe what you see.

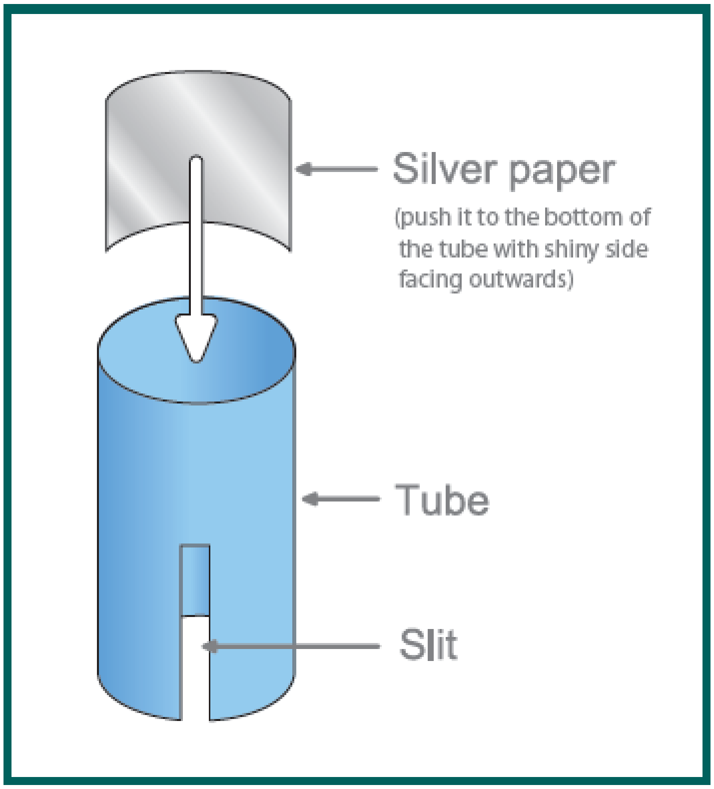
Bubbles

1. Empty half a cup of cold tap water into a bowl and place it in the middle of the table.
2. Add some washing up liquid.
3. Take a length of garden wire and carefully twist it into a looped shape.
4. Dip it into the bubble mixture to get a film and then hold it up to the light and observe. Discuss what's happening. Where else do you see similar effects?

Scatter tubes

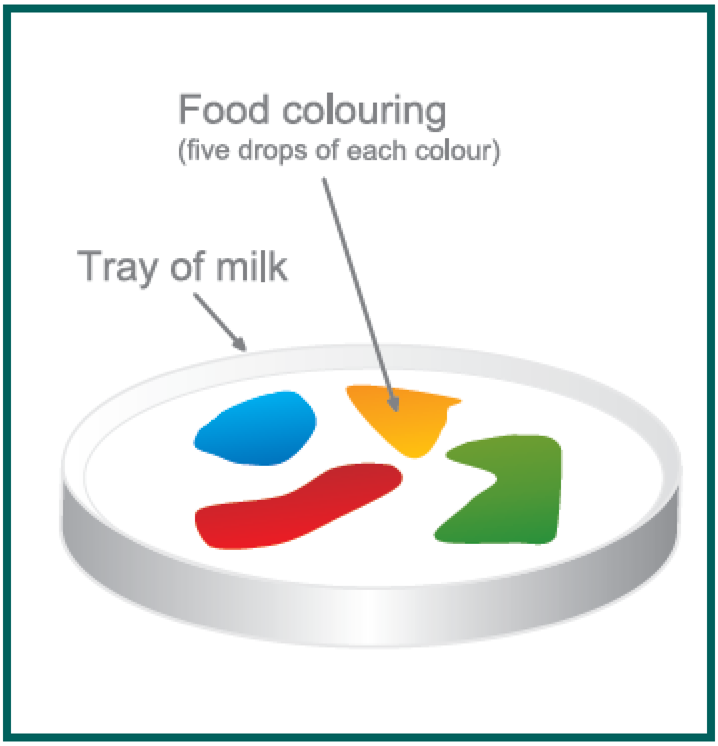
1. Take the piece of card and bend it to make a short fat tube.
2. Stick it in place using tape.
3. Cut an opening in the tube at one end by making two slits, lifting the flap and cutting it off.
4. Fix the piece of silver paper on the inside of the tube at the back opposite the opening.
5. Stand the tube on a white surface and shine the torch through the opening and look down the top of the tube.
6. Record your observations and discuss the results.

How do these compare with those in the bubble experiment?


Silver paper
(push it to the bottom of the tube with shiny side facing outwards)
Tube
Slit

Multi-coloured milk

1. Pour the milk into a clean shallow tray so that it covers the bottom. Make sure there are no traces of washing up liquid in the tray.
2. Add five drops of one food colouring on top of each other in one quarter of the tray.
3. Repeat with the other colours so you have four separate puddles of colour in the milk.
4. Add one drop of diluted washing up liquid to the centre of the tray and watch what happens. Can you suggest why this happens?
5. Add a further drop of washing up liquid onto each colour and observe.



Activity 3: Flame Tests

Introduction

This experiment shows the flame colours given by alkali metal, alkaline earth metal, and other metal, salts.

Procedure

A supply of wooden splints has been thoroughly soaked in the solutions below for at least 24 hours.

Li^{+}	Ca^{2+}	K^{+}	Ba^{2+}	Cs^{+}
Na^{+}	Sr^{2+}	Rb^{+}	Cu^{2+}	Pb^{2+}

Each 'station' around the lab consists of a boiling tube of one of the above solutions in a rack (labelled with name and symbol of cation (metal) plus appropriate hazard warnings. A Bunsen burner, heatproof mat and container for disposal of used splints will also be needed. One station is set up with distilled water as a control and another with a solution labelled as 'unknown'.

Holding a soaked splint in a blue flame then reveals the flame colour. Complete the table above with the colour you observe for each metal.

Watch the splint carefully, so that it is not held in the flame long enough to burn.

Identify the unknown.

Activity 4: Dyeing – three colours from the same dye-bath

Samples of different fabrics are placed in a single dye bath containing three dyes. The materials emerge dyed different colours, illustrating how dyeing involves specific chemical interactions between the dye and the molecular nature of the fibre.

Procedure

a) If the dye bath has yet to be prepared, dissolve 0.02 g of each of the red and yellow dyes and 0.03 g of the blue dye in 200 cm^3 of water in a beaker, add a few drops of dilute hydrochloric acid and heat to boiling.

b) Place a sample of cotton, cellulose acetate and either wool, silk or nylon in the dye bath and simmer gently for about 10 minutes.

c) Remove the fabrics with forceps or tongs, rinse under running water, and hang up on the 'clothes line'. Cotton will be dyed red, acetate yellow and wool, silk or nylon blue-green. (Some of the yellow direct dye will take to these materials as well as the blue acid dye.)

d) Try other materials as well if desired. Polyester will be dyed yellow and polyester/cotton will become orange.

e) Now examine the effect of the dyes individually. Make three dye baths, the first containing 0.02 g of red dye in 200 cm^3 of water, the second containing 0.02 g of the yellow dye in 200 cm^3 of water and the third containing 0.03 g of the blue dye in 200 cm^3 of water. Add a couple of drops of hydrochloric acid to each dye bath and heat to boiling.

f) Place a sample of each fabric in each dye bath and treat as before, ie simmer for 10 minutes, remove the samples and rinse. Typical results are shown in the table.

Dyes	Silk	Wool	Nylon	Cotton	Acetate	Polyester	Polycotton
Mix	olive-green	olive-green	olive-green	red	yellow	yellow	orange
Red	pale orange-red	pale orange-red	pale orange-red	red	almost white	pink	pink
Blue	blue	blue	blue	very pale blue	white	white	almost white
Yellow	orangey	orangey	orangey	pale yellow	bright yellow	bright yellow	bright yellow

Different dyes bond to fabrics in different ways.

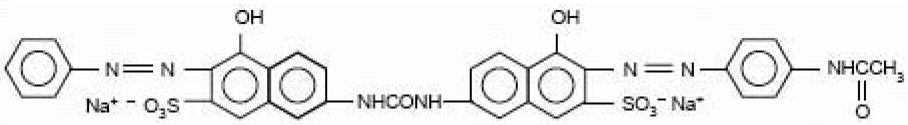
• Acid dyes contain acidic $–CO_2H$ and $–SO_3H$ groups which bond to the basic –NH groups in the amide linkages of wool, silk and nylon.

• Direct dyes bond by hydrogen bonding and take well to cellulose-based fibres such as cotton, viscose and rayon which have many –OH groups.

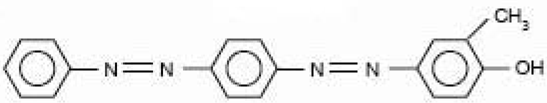
• Disperse dyes are not water-soluble. They exist in the dye-bath as a fine suspension (hence the name), and are absorbed as a solid solution by hydrophobic fabrics such as polyesters.

Consider the chemical structures of different types of fibre, use this knowledge to predict the effects on other fabrics, for example on silk and nylon, which are polyamides like wool. Also predict the effect of the dyes on a mixed fabric, such as cotton-polyester. Offer a possible explanation for some odd effects in washing machine accidents, where labels and trim may emerge a different colour to the rest of the garment.

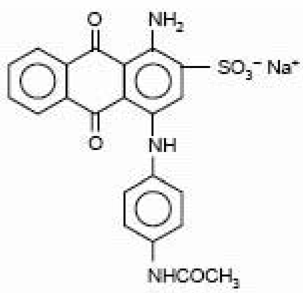
The structures of the dyes used in this experiment are:



Direct red 23



Disperse yellow 7



Acid blue 40

Below are various investigations for you to consider:

1 Devising mixed dye-baths to produce different colours to the ones demonstrated using the chemical principles fabrics described above.

2 Investigating the effect on the colours produced in different fabrics of:
- mordants such as salt or alum (**Low hazard**, refer to CLEAPSS Hazcards 47B or 2B)
- pH of the dye bath
- time in the dye bath
- temperature of the dye bath

3 How fast (resistant to washing out) are the dyes to a variety of treatments?

A good account of which types of dyes dye which fabrics is given in The Essential Chemical Industry, p 42. University of York: The Chemical Industry Education Centre, 1989.

Kemtex Educational Supplies (see website address below) provide kits of dyes and fabrics for similar demonstrations.

Web Links

Kemtex Educational Supplies (http://www.kemtex.co.uk) provide a range of information sheets about dyes and dyeing, and related processes such as transfer printing, as well as supplying a wide range of dyes to school Art & Design and Textile Departments.

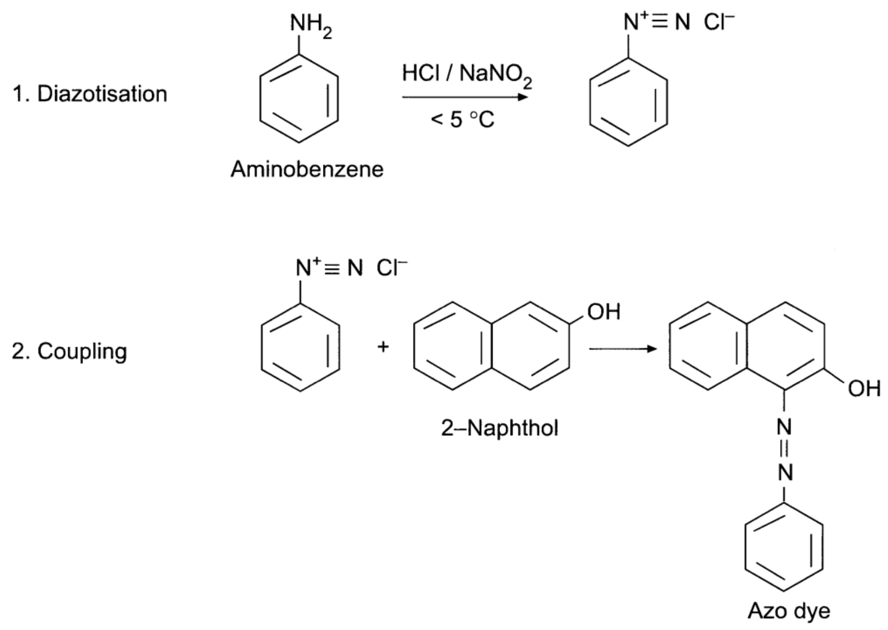
The Bakken Library in Minneapolis, USA (http://www.thebakken.org/education/SciMathMN/plant-dyes/dyes1.htm), provides a cross-curricular unit called ‘A Lesson to Dye For’, which also highlights investigative skills. The level of chemistry is not high, but the range of ideas is very wide, and teachers may find some useful ideas for follow-up work.

The University of Regensburg, Germany (http://www.uni-regensburg.de/Fakultaeten/nat_Fak_IV/Organische_Chemie/Didaktik/Keusch/D-Video-e.htm), provides a wide range of video clips of chemistry experiments at an advanced level, including a number relating to dyes and dyeing.

Activity 5:The microscale synthesis of azo dyes

In this experiment you are to prepare an azo dye and use it to dye a piece of cotton. The synthesis is unusual in that whereas most organic syntheses require ambient or elevated temperature, this synthesis requires low temperatures.

The reactions are:



Instructions

1. Put eight drops of aminobenzene in a 10 cm^3 beaker and add 30 drops of deionised water followed by 15 drops of concentrated hydrochloric acid. Swirl the beaker and then put it in an ice bath.
2. Weigh 0.15 g of sodium nitrite into another beaker and add 1 cm^3 of deionised water. Cool the beaker in the ice bath. Add one spatula of urea (this prevents side reactions occurring).
3. Mix the contents of the two beakers together and keep in the ice bath.
4. Weigh 0.45 g of 2-naphthol into another beaker and add 3 cm^3 of sodium hydroxide solution. Swirl to dissolve.
5. Take a piece of cotton cloth 2 x 2 cm^2 and, using tweezers, dip it into the 2-naphthol solution. Allow the solution to completely soak the cotton.
6. Dip the cloth completely into the diazonium salt solution. A red dye forms in the fibres, dyeing the cloth.
7. Take the cloth out, wash it under the tap and leave to dry

References

S. W. Breuer, Microscale practical organic chemistry. Lancaster: Lancaster University, 1991.

Glossary

Absorption spectrum	The absorption spectrum is primarily determined by the atomic and molecular composition of the material.
Anion	An ion with more electrons than protons, giving it a net negative charge.
Azo dye	Azo dyes are compounds containing the functional group R-N=N-R', in which R and R' are either an aryl or alkyl group.
Cation	An ion with fewer electrons than protons, giving it a positive charge.
Emission spectrum	The spectrum of electromagnetic radiation emitted by an atoms or a compound's molecules when they are returned to a lower energy state.
Ionisation	The process of converting an atom or molecule into an ion by adding or removing charged particles such as electrons.
Redox	A process that involves reduction and oxidation.
Spectrometer	An instrument used to measure properties of light over a part of the electromagnetic spectrum.

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