Student Sheet

In this practical I will be:

- Observing and reporting on the findings from the experiment.
- Comparing, contrasting and grouping different materials based on my results from the experiment
- Using my scientific understanding to explain the results of the experiment.

Introduction:

Whilst washing your linen clothes in the tub, you notice that the dyes from a few items of clothing have begun to run and colour the water. You think nothing of it and continue to wash your clothes. When you pull some of clothing out of the coloured water, you observe that something very interesting has occurred. Like all good science-artists, you decide to investigate further.

Equipment:

- 4 beakers (400 cm^3) (or 3 beakers (250 cm^3))
- 4 disposable plastic pipettes
- Stirring rod
- 4 large watch glasses or Petri dishes
- 1 pair of tongs or tweezers
- 1 pair of scissors
- Access to a top pan balance (if preparing from solid)
- Spatula (if preparing from solid)
- Weighing boat (if preparing from solid)
- Bottle of distilled water
- Thermometer
- Bunsen burner
- Tripod
- Gauze
- Heat proof mat
- String and paper clips, to make a ‘washing line’
- Crocodile clips or clothes pegs

Wear disposable gloves

The quantities given are for one demonstration.

- Samples of the following fabrics in white: wool, silk, nylon, cotton, polyester, cellulose acetate (‘triacetate’), polyester/cotton mix. About 1 cm^2 of each fabric or a few cm of thread will be sufficient.

- 0.05 g of each of the following dyes:
    - acid blue 40 (low hazard)
    - disperse yellow 7 (irritant, wear safety glasses)
    - direct red 23 (low hazard)
    - or 10 cm^3 solutions of each of the dyes ready prepared (per group)
- A little dilute hydrochloric acid (0.1 M)
- Sodium chloride (if carrying out the extension activity) (low hazard)
- Alum (if carrying out the extension activity) (low hazard)

Method

1. Cut four strips of each material (about 1 cm x 1 cm is suitable). 1 cm^2 is enough for groups to use. Larger pieces for a demonstration.
2. Each fabric should be easily identifiable in some way for example by cutting different shapes.
3. Weigh out two samples of 0.02 g of each of the red and yellow dyes and two samples of 0.03 g of the blue dye.
4. 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 distilled water. Or add 1 pipette of each dye (approx. 2-2.5 cm^3) to 200 cm^3 of water.
5. Add a few drops of dilute hydrochloric acid, stir, and heat to boiling.
6. Place a sample of cotton, cellulose acetate and either wool, silk or nylon in the dye bath.
7. Simmer gently for about ten minutes.
8. Remove the fabrics with tweezers or tongs.
9. Rinse the clothes under running water.
10. Try other materials as well if desired.

Going further

Mixed dye-baths that produce different colours to the ones suggested here can be devised using the principles governing what dyes colour each of the fabrics described above.

Examine the effect of the dyes individually.

1. Make three separate dye baths, the first containing 0.02 g of red dye in 200 cm^3 of water. Or 1 pipette of dye in 200 cm^3 of water in a beaker.

2. The second containing 0.02 g of the yellow dye in 200 cm^3 of water. Or 1 pipette of dye in 200 cm^3 of water in a beaker.
3. The third containing 0.03 g of the blue dye in 200 cm^3 of water. Or 1 pipette of dye in 200 cm^3 of water in a beaker.
4. Add a couple of drops of hydrochloric acid to each dye bath.
5. Place a sample of each fabric in each dye bath and treat as before, ie simmer for ten minutes.
6. Remove the samples with tweezers or tongs and rinse.

Do mordants such as salt or alum have any effect?

Does pH have any effect? Does the time in the dye bath or the temperature of the dye bath have any effect?

How fast are the dyes to a variety of treatments?

Theory:

Different dyes bond to fabrics in different ways.

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.

Polyester will be dyed yellow and polyester/cotton will become orange.

Acid dyes contain the 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.

Acknowledgements: Based upon *Classic Chemistry Demonstrations* Royal Society of Chemistry.