Perkin's Mauve

Contents: Practical work, reading and questions concerning the discovery of the first synthetic dye.

Time: 2 periods for practical work. Reading and questions need a further 1 to 2 periods, though homework time could be used. There are many opportunities for extension.

Intended use: GCSE Chemistry and Integrated Science. Links with work on chemistry of carbon compounds.

Aims:

- To show an important application of carbon chemistry: the production of synthetic dyes
- To illustrate the human side of scientific discovery through the story of William Perkin
- To show the historical and social impact of the development of the dye industry
- To provide opportunities to practise certain practical skills, and skills in reading and comprehension.

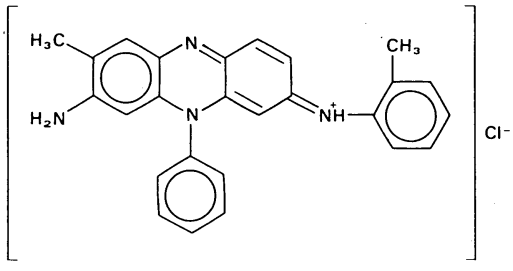
Requirements: Students' worksheets No. 510. For practical requirements, see below.

Dyeing experiments are fun and are enjoyed by girls and boys of all abilities. It is recommended that all students do the experimental work, since this will make the reading more interesting.

Notes on the reading and associated questions

The molecular formula of quinine was thought in Perkin's time to be $C_{20}H_{22}O_2N_2$. This is two hydrogen atoms short, and in any case the structural formula was unknown. The artificial synthesis of quinine was in fact not achieved until 1944.

The structural formula of mauve is:



Q.2 The development of synthetic dyes marked the beginning of the modern organic chemical industry. Britain was so committed to Industrial Revolution industries such as steel and textiles, and to colonial enterprise, that it was left to Germany to develop the British initiative, leading to the founding of such giants as BASF (Badische Anilin und Soda Fabrik) and Agfa. This led to the situation where, by the time of the First World War, Britain was importing most of its dyes from Germany, including those used to dye military uniforms.

Q.3 The first two 'coal tar' dyes, mauveine and magenta, were made from aniline, itself made from benzene extracted from coal tar. Today, petroleum is the source of benzene, though coal tar may again become important as oil supplies run out.

Q.6 Other examples of chance discoveries include Fleming's discovery of penicillin and Plunkett's discovery of p.t.f.e.

Notes on the experimental work

Each group of students will need:

beaker, 400 cm^3
conical flask, 250 cm^3
filter funnel
small piece of silk
boiling tube and glass rod
hot water bath

access to:
aniline sulphate (phenylammonium sulphate)
potassium dichromate
ethanol (with measuring cylinder to measure 25 cm^3)
paper towels or blotting paper
filter papers

Note that cotton, silk and other fabrics can be obtained cheaply at the remnant counters of large department stores. These fabrics have often been treated with surface dressings to improve the finish. Untreated fabric is best for dyeing experiments.

The Investigations provide an opportunity for students to design and carry out comparative tests. Fastness testing could be done at home. Small samples can be stitched or stapled to a larger piece of white cloth for testing fastness to washing. For light fastness it is convenient to cover the samples with a piece of card with small holes cut in it and then to expose them to light on a window ledge. After a few weeks some dyes will show marked fading and it is easy to compare the exposed portions with the areas hidden under the card.

Further experimental work

There is plenty of scope for further experimental work. See, for example:

Revised Nuffield Chemistry, Option 10, *Historical Topics*
Science at Work, Dyes and Dyeing (Longman)

Further resources

Revised Nuffield Chemistry, Option 10, includes further background to Perkin's discovery.

Revised Nuffield Advanced Chemistry, Book II, Topic 17, gives details of the chemistry of dyes which may be useful background for the teacher, as well as further experimental work.

The Colour Chemists, by A S Travis (ASE) has a detailed account of the historical development of the synthetic dye industry.

Acknowledgements Figure 1 supplied by the Mansell Collection; Figure 2 supplied by the Science Museum; Figures 3 and 4 reproduced by permission from *Punch.*

PERKIN'S MAUVE

William Perkin (1838–1907) is famous because he discovered the first synthetic dye. He made the dye by mistake when trying to find a way to make quinine.

Figure 1 William Perkin, aged 14, in a photograph he took himself

Before Perkin's discovery, all dyes came from natural sources. Some examples are given in Table 1. Many people like the colours of natural dyes, including the indigo used to dye blue jeans. But the colours of these dyes are dull and limited in range. Also, natural dyes are not **fast**. This means that they fade when repeatedly washed or when exposed to sunlight.

Table 1 Some natural dyes

Dye	*Source*	*Notes*
Indigotin	The indigo plant in India or the woad plant in Europe	In 1897, German dye manufacturers first marketed synthetic indigo. All the indigo used to dye blue jeans is now made synthetically.
Alizarin	The roots of the madder plant	The traditional source of good red dyes. It can also be used to dye cloth orange, brown, or purple depending on the conditions.
Cochineal	A Mexican insect	A scarlet or crimson dye which was used to colour the red coats of the British army. It is still used as a food colour.
Logwood	A South American tree	One of the few natural dyes which still has commercial importance. It can be used as a black dye for nylon and cotton.

How Perkin discovered mauve

Perkin's interest in chemistry started at school. At the age of 15 he entered the Royal College of Chemistry as a student. He was assistant to the famous chemist, August Hofmann. Perkin was so keen that he set up a laboratory at home so that he could carry out experiments in his spare time. It was in his own rough laboratory that he discovered his new dye in 1856.

At that time Perkin was excited by the idea of finding artificial ways of making natural substances. Quinine had been used for two hundred years to treat malaria. It was obtained from the bark of a tree, but had only been separated in a pure state in 1817. Perkin failed to make quinine. This is not surprising, because no one knew its exact formula at that time. But it was during investigations that he discovered mauve — by accident.

Perkin was heating a mixture of aniline sulphate and potassium dichromate. He got a black precipitate. Instead of just throwing this away he decided to investigate it. He added some alcohol and found that he could extract a beautiful purple coloured material from the black mess. He then found that the material could be used as a dye. What is more, it was fast to light.

Perkin sent samples of dyed silk to a commercial firm of dyers. They were very interested because there were then no lilac or purple dyes for cotton or silk. This encouraged Perkin. He and his brother scaled up the process so they could make more of the dye. They patented the discovery.

At this point Perkin decided to leave the Royal College of Chemistry. His father, a builder, was willing to risk money to help establish a new firm to manufacture the dye. Perkin and his brother bought a site near Harrow and began building a factory in 1856 (Figure 2).

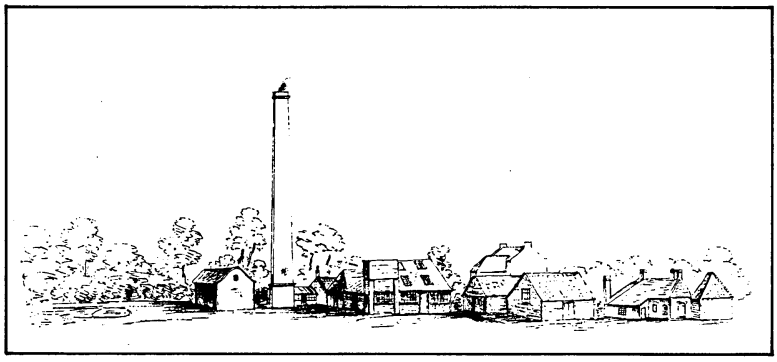
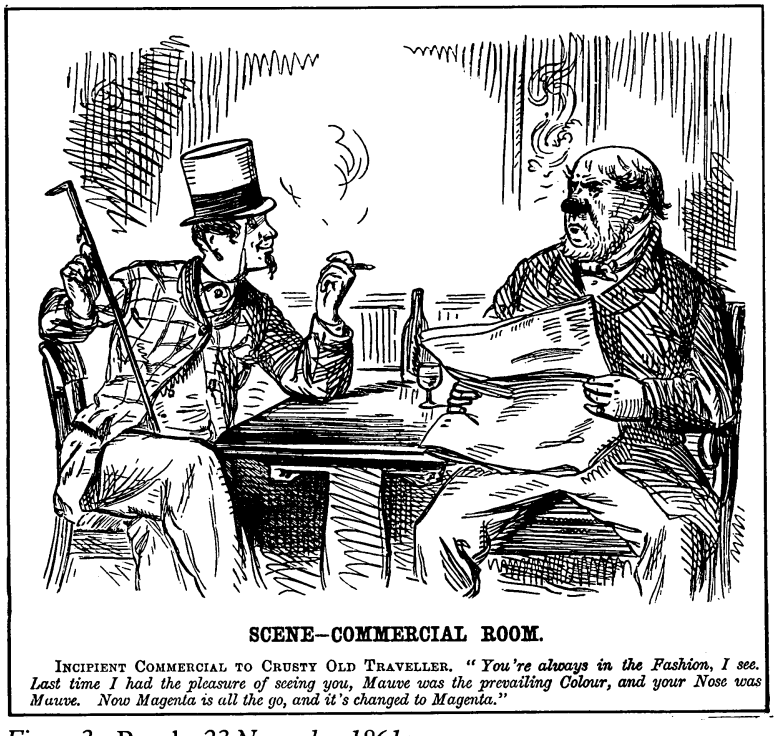


Figure 2 A sketch by W. H. Perkin of his first artificial dye factory in 1858

Mauve becomes famous

Perkin's new dye was called **mauveine** and it became very fashionable. Queen Victoria wore a mauve dress at the International Exhibition of 1862. The penny mauve stamp was printed in 1881. The new colour had a big impact on society. There were many references to it in *Punch* and other periodicals (Figures 3 and 4).



SCENE—COMMERCIAL ROOM.

INCIPIENT COMMERCIAL TO CRUSTY OLD TRAVELLER. *"You're always in the Fashion, I see. Last time I had the pleasure of seeing you, Mauve was the prevailing Colour, and your Nose was Mauve. Now Magenta is all the go, and it's changed to Magenta."*

Figure 3 Punch, *23 November 1861*

Perkin's discovery soon led to many others. In 1859 a French chemist called Verguin discovered a dyestuff which he called **magenta**. Hofmann was able to produce a series of new dyes by altering the structure of magenta.

GREEN GO THE LASSES, O!

FTEN have we heard of countless accidents by Crinoline, but Crinoline is not the only cause of danger in a lady's dress. At least a correspondent who writes to a contemporary, and appends his name with the affix of "M.D.," gives some rather startling reasons for believing so. After stating that the fashionable *mauve* tint, and *Magenta*, "will not stand the test of artificial light," he proceeds next to remark that—

"The only colour, perhaps, which remains fixed under all kinds of light is what is known as 'SCHEELE'S green.' This colour, which is pleasingly bright in the day, is made of arsenic, and preserves its freshness and beauty under all trials of artificial light. Now, as Paterfamilias probably knows, if he looks into his wife's account with her milliner, there is a new light stuff called tarlatane, which has recently come very much into vogue. A lady in proper fashion, with a good green tarlatane dress, is surrounded by 92 square feet of tarlatane, and this 92 square feet of tarlatane contains, as a chemical fact, about 13 ounces of arsenic! Fancy a bevy of a dozen or two of such young ladies 'in verdure clad' of this kind, and that at every crush of their dress, every toss of it in a quadrille, this arsenic is given off in poisonous dust, and that this dust is the fruitful source of headache, redness of skin, inflammation of the stomach, consumptive cough, &c."

With this knowledge in his mind, we think a man would be as green as the dress of his fair partner, if he either waltzed or polked with a lady in SCHEELE'S green. In fact, girls in these green dresses ought to be marked "DANGEROUS!"

Figure 4 Punch, *5 October 1861*

Perkin's factory was a commercial success and he was soon rich. However, he had a lot of competition from other companies, particularly German ones. The Germans were much quicker to develop the dye industry than the British. There was not much interest in the dye industry in Britain. This was because iron, steel, textiles, shipbuilding and colonial industries were so profitable. Perkin sold the business after a few years and continued research in his private laboratory.

At this time chemists were getting a better understanding of the structure of substances. They were soon able to plan their approach to making new molecules, so that new dyes could be made by design rather than by accident.

Questions

1 *Why was the discovery of synthetic dyes so important?*

2 *Why did Germany develop the synthetic dye industry quicker than Britain?*

3 *Mauve was made from aniline and in 1856 aniline was produced from coal tar. So mauve was the first of the 'coal tar' dyes. What is the main source of chemicals for the synthesis of dyes, drugs and plastics nowadays?*

4 *How old was Perkin when he discovered mauve?*

5 *In what ways can young people of school or college age make a lot of money from science or technology today?*

6 *Perkin seems to have discovered mauve by chance. Give another example of a chance discovery in science.*

7 *How many colours of cloth have been used to make the clothes you are wearing? What are the colours? Are the dyes likely to be synthetic or natural?*

Making Perkin's mauve

In this experiment you will use roughly the same method as William Perkin used when he discovered his mauve dye in 1856.

What you do

Follow the instructions shown in Figure 5.

Caution: Safety. Aniline sulphate and potassium dichromate are harmful. Avoid skin contact with these chemicals. Ethanol is highly flammable and must only be heated with a hot water bath. Make sure no burners are alight when the ethanol is being heated.

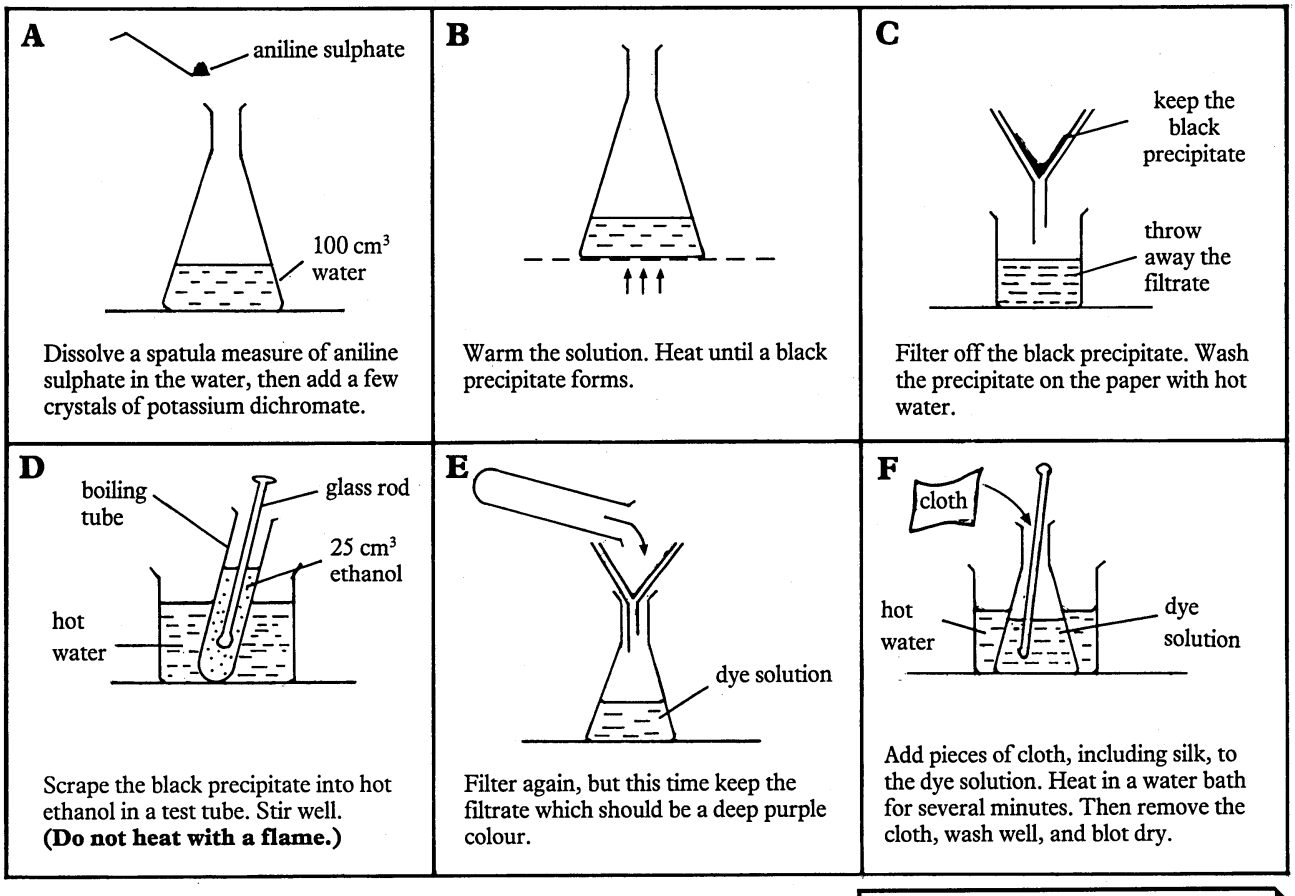


Figure 5 Making Perkin's mauve

Investigations

1 Dye different types of material (for example cotton, silk, nylon, wool, polyester) with Perkin's mauve. Which type of material takes the colour best? (Which of these fabrics would have been available in Perkin's time?)

2 Perkin's discovery was valuable because the dye was fast — it did not fade. Design tests to see how fast your dyed samples are when (a) washed; (b) exposed to light.

Questions

8 *At the end of stage B could you see any signs of a purple colour in the black precipitate? If you had been Perkin would you have had the idea of looking for a dye in the black mess?*

9 *What would be the difficulties of 'scaling-up' this procedure for large-scale manufacture? How is filtering carried out on an industrial scale? How could the ethanol be recovered for re-use?*

SATIS 5

List of units in this book.

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ISBN 0 86357 041 0