Microscale chemistry revisited

Microscale techniques are unlikely to replace our traditional approach to chemistry education, but they do provide an extra dimension to our teaching strategies

Bob Worley

Looking at photographs of school chemistry laboratories before the second world war, you see Bunsen burners, tripods, and other very familiar apparatus still used today. Other sciences have seen more dramatic changes; physics with electronics, lasers and radioactivity and biology with aseptic techniques. Bunsen burners, tripods, burettes still work well but other practical methods are available which provide more variety in presenting practical chemistry to students.

Emergence

I remember a note coming to my chemistry department when I was teaching in the 1980s, to inform me that the demonstration involving passing hydrogen over hot copper(II) oxide to form copper and water was banned because there had been a serious incident resulting in a prosecution by the Health and Safety Executive. A hydrogen/air explosion had caused concentrated sulfuric(VI) acid (used to dry the hydrogen) to spray over the children, who were not wearing eye protection. Of course, it was not banned. It was the usual over-reaction to incidents caused by poor attention to detail by a teacher. However, the demonstration did fall from favour and, without a hydrogen cylinder, it is complicated to set up.

In the 1990s, ‘out of Africa’ came a kit (fig 1) from the Radmaste Institute1 which allowed students to carry out this same reaction safely in microscale. The kit is available in this country and a number of enthusiastic users use it regularly.2

I developed another safe microscale method of reducing...
Electrolysis

The electrolysis of metal chloride solutions produces chlorine (toxic) gas, a potentially unsafe procedure in an open laboratory. A microscale approach can solve the safety issues. It could be carried out by pupils (if they have no reaction to the 6 cm³ of chlorine produced) or it can be demonstrated and projected via a microscope or visualiser onto a screen.

The electrodes are made of carbon fibre, available from any online kite shop at about £5 for 1 m of 1 mm diameter rod. It is very flexible and strong and can be cut with scissors to the required length. Holes are drilled or burned through the opposite sides of a 90 mm diameter plastic Petri dish.

In the Petri dish, a piece of damp blue litmus, a drop of 0.1 M potassium iodide and a drop 0.5 M potassium bromide solution are used to detect the chlorine coming off (fig 4a). About 0.5 cm³ of 0.5 M copper chloride solution is placed between the electrodes and the lid is put on. The electrodes are attached to a low voltage supply or battery. Chlorine diffuses within the dish and reacts (fig 4b) with the solutions and litmus paper. Copper appears at the cathode (fig 4c). Obviously, other salt solutions can be used. A video is available.

Indicators

The Comboplate (fig 5) from the original kit can be bought separately. To show the range of colours of indicators as shown in fig 5, solutions in the larger well plates are prepared by mixing (20 – x) drops of acid solution A with x drops of alkaline solution B delivered by a
plastic 3 cm³ pipette. The value of x changes by 2 drops per well. After measuring the pH with a pH meter (optional), 3 drops of each well solution are transferred to the smaller wells above. The indicator is then added to obtain the beautiful array of colours. This procedure can be used not only at KS3 to demonstrate the colours of indicators but also (with adaption) at A-level to calculate pKₐ values.

The upside

Microscale techniques will never replace our traditional approach but they do provide an extra dimension to our teaching strategies. Students, in extended studies, could compare the quantitative results with established methods to crucially examine sources of error. With jewellery balances weighing to 3 decimal places (capacity 20 g) available at £40, the study becomes feasible in all schools.

The procedures are extremely economical and answer environmental issues such as energy consumption and waste. As Stephen Breuer wrote ‘if you need 100 mg, make 100 mg, don’t make 5 g and throw away 4.9.’

If a microchemical approach satisfies one or more of the following points it should be seriously considered.

1. It allows a once-dangerous experiment to be carried out more safely
2. It shortens practical time so that lessons are not so rushed
3. It reduces the cost of equipment and consumable materials
4. Users report a higher level of concentration amongst pupils and mistakes are quickly rectified
5. It enables some stunning visual effects when filmed or projected onto a whiteboard
6. It reduces technician time in disposing and clearing up
7. It reduces waste, a factor which is becoming more important in the UK. (We would, in fact, consider many other countries to be draconian in their constraints on waste from a school laboratory.)
8. It shows equivalent or better quantitative results (although comparison of techniques is a useful exercise in error analysis)
As to dexterity; if students in other countries can cope, why cannot our pupils learn the techniques? It is often the teacher who lacks the techniques, experience and dexterity.

Janice Griffiths at the South East Learning Centre contacted some teachers who had attended a microscale course. All replies were positive and here is one statement:

The colour of indicators (fig 5) has provided possibly our first practical assessment for year 7s. They love it. Our science technician loves it and we promote the idea of reducing materials and potential risks. I think it should be used in teacher-training establishments. It’s rare for me to feel I obtain value for money from an Inset but I was really inspired by this one.

**Conclusion**

Microscale techniques have been introduced as a matter of necessity in many countries because they do not have teaching laboratories. I came to the technique from a health and safety angle as a direct response to carrying out risk assessments.

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### Fig 5

A Comboplate used to show the colours of indicators

**Key:** Bromothymol blue (A), methyl orange (B), phenolphthalein (C), universal indicator (D) and pH values (E, F)

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### REFERENCES

1. www.radmaste.org.za
2. Education in Chemistry, March 2007, p45
3. CLEAPSS, Safer chemicals, safer reactions (guide L195), 2006
4. www.cleapss.org.uk

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**Simon Cotton looks at compounds in the news or relating to our everyday lives.**

**In this issue:** Strychnine

If you were asked what the first Olympic performance enhancing drug was, you might think of an anabolic steroid, perhaps or maybe an amphetamine? It was, in fact, strychnine!

**I THOUGHT THAT STRYCHNINE WAS POISONOUS?**

It is – a dose of around 50 mg can be lethal, but at much lower doses it acts as a stimulant, and it was used as such in Victorian times. Stimulant tablets containing strychnine continued to be sold as proprietary tonics well into the second half of the 20th century.

**WHO USED IT?**

The British-born American marathon runner Thomas Hicks, won gold at that event in the 1904 Olympic Games, held at St Louis, Missouri. The race was held on a dreadfully hot day – over 32°C – on a dusty track of a course.

Olympic runner Thomas Hicks had a dreadfully hot day – over 32°C – on a dusty track of a course.

**AND HE FINISHED FIRST?**

He actually came in second, but still won the Gold medal because Fred Lorz, who came in first, was found to have covered nearly half the course in a car.

**SO HICKS WENT ON TO HAVE A SUCCESSFUL ATHLETIC CAREER?**

No, he seems to have given up athletics the following year, and lived to the age of 88.

**WHY IS STRYCHNINE SO TOXIC?**

It particularly affects the motor nerves in the spinal cord, and these control muscle contraction. It binds to a glycine receptor. The strychnine does not stop glycine from binding, but actually means that nerve impulses are passed along at much lower neurotransmitter levels.

People with strychnine poisoning have violent convulsions with arching of their back; their jaw muscles contract, so they die with a dreadful grin on their face.

**HOW DOES IT ENHANCE PERFORMANCE, THEN?**

It seems possible that it is linked with the effects of strychnine on the nervous system, but no one knows for sure.