Small is beautiful

When we think of chemistry, we often tend to think of the big, spectacular reactions that are usually done as demonstrations where the whole object is to impress. Most chemistry work as carried out by pupils is done so at a smaller scale but it will still often use quite large amounts of reagents. There is, however, another way...

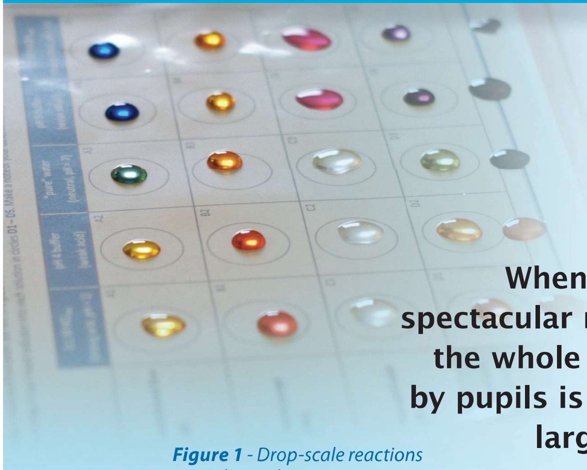

Figure 1 - *Drop-scale reactions on a plastic sheet.*

Microscale chemistry came on the scene in the 1980s but, in Europe and America at least, it remained a niche activity. Then, in the mid 2000s, green chemistry came on the scene in a big way and the green credentials of microscale gave it a new lease of life. (At this point, we would like to thank Bob Worley from CLEAPSS who has spent many years developing microscale chemistry activities for schools and has been generous enough to share them with us [1]).

It seems to us that while there will always be a place for large scale chemical work, microscale chemistry for schools in the UK is an idea whose time has come. Therefore, there is now a section of the Chemistry area of the website devoted to microscale chemistry with details of equipment and preparation as well as experiments [2].

Why microscale?

1) Safer procedures
Microscale procedures are usually safer than the original reactions because of their size.

2) Less waste
Dealing with waste is of great concern in all countries now. Using smaller amounts produces smaller amounts of waste. This in turn reduces time in preparation, clearing up and disposal.

3) Reduces cost
Microscale equipment is mostly plastic and inexpensive. Working on a microscale means using smaller quantities of sometimes expensive chemicals. In addition, the reduction of waste as mentioned above can reduce disposal costs.

4) A laboratory is not always required
This is not always desirable but it can be very useful at times to be able to carry out some practical work when you do not have access to a dedicated laboratory.

5) Reduces practical times
If demonstrations and practical procedures take too long and have to shelved to the next lesson, continuity is lost and the subject can become disconnected, not understood and potentially boring. Also, less time spent on the mechanics of the experiment allows for more discussion and questioning

6) Better classroom control
Much of the time wasted in lessons is caused by students moving around the room to find sinks and balances and collecting chemicals and equipment. This can lead to poor behaviour but microscale activities can be carried out in a small area of the room. Another revolution is that as the quantity of liquid used is at most 2 cm^3, with practiced techniques, students can sit down to carry out the activity.

Despite the small scale and the generally inexpensive equipment, a lot of good, quantitative results can be achieved by these methods, comparable in many cases with the full-scale approach.

Figure 2 - *Gas reactions contained in a Petri dish.*

Problems?

The fact that it is on a very small scale does mean that there are issues with using this technique for demonstrations. It is possible to get around this though. Images can be projected onto a white board using a webcam or video microscope.

Another problem is that using very small quantities can raise problems with dexterity for some pupils. Like any other skills, however, this is one that can be improved with practice.

Some microscale techniques

There are many experiments that can be done successfully on a microscale. There are more than 20 on the SSERC website with more to follow. Here, though, are a few general approaches to microscale chemistry.

1) Using drops on plastic sheets
- For many reactions normally carried out in test tubes, reducing the scale so that mere drops of solutions are used is an excellent approach (Figure 1).

Figure 3 - Burning a syringe of propene.

The instructions are printed on an A4 sheet which has spaces marked on it for the placement of drops of reagents. These can either be laminated or simply placed inside a plastic wallet. The great advantage here is that the instructions are immediately adjacent to the reaction so fewer mistakes are likely.

2) Using Petri dishes to contain gases - using microscale quantities of reagents can allow hazardous gases such as ammonia, and hydrogen sulfide to be investigated in the open laboratory. Placing the reagents in a Petri dish (Figure 2) allows the gases to be largely contained which provides a relatively high concentration within the dish to facilitate reactions while maintaining a safe environment outside. *(Figure 2 also shows the use of a section from a 'blister pack' for tablets being used as a micro reaction vessel - in this case to generate ammonia.)*

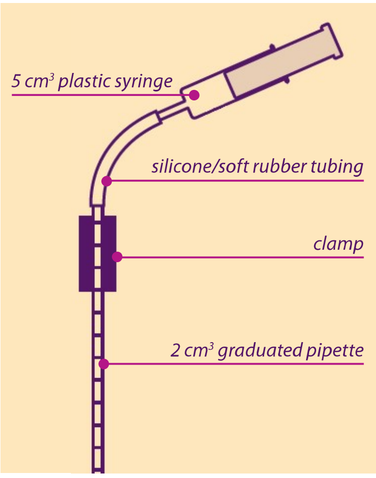

Figure 4 - Micro-titration using a glass pipette.

3) Using syringes to handle gases - Luer lock syringes in particular are ideal for holding and dispensing small samples of gases (up to 50 cm^3 or so). For instance, syringes of hydrogen can be used for a microscale reduction of metal oxides.

4) Microscale titrations - These can be carried out in two ways:

a) Using a glass pipette and a syringe (Figure 4).
The titrant is drawn up into the pipette and then slowly pushed out, instead of using gravity, during the titration. The scale allows readings to 0.01 cm^3.

b) Using a pasteur pipette.
This time the titrant is drawn up into the pasteur pipette and dispensed drop by drop. Counting the drops is a good proxy for volume (a quick experiment beforehand will tell you the volume per drop). A standard 1 cm^3 Pasteur pipette will give you an accuracy of about 0.04 cm^3, while a fine tip one will be accurate to 0.02 cm^3). For more control, the bulb of the pipette can be placed in a clamp which is slowly tightened (Figure 5).

As an alternative in both methods, the titration can be carried out on a balance and the change in mass measured instead - for dilute solutions, it is quite acceptable to take the density as being 1 g/cm^3 (the same as water).

5) Bottletop crucibles
Crucibles are a bit of a nuisance. Nickel ones are expensive and the porcelain ones break easily (being only intended as single use by the manufacturers!). In addition, they both have a tendency to fall off tripods too easily.

Figure 5 - Micro-titration using drops from a Pasteur pipette.

It is possible to get a microscale crucible quite easily from a muselet (the metal cap and wire from bottles of sparkling wine (Figure 6) and a few beers). The wire holder provides a handy grip for a pair of tongs or a clamp. For experiments like the burning of magnesium that requires a lid, it is possible to use crown corks (the tops from beer bottles and the like), two of which can be held together with a bit of nichrome wire (Figure 7).

We hope this article will open your eyes to the usefulness of the microscale approach to teaching chemistry and that, some of the time at least, small can be beautiful.

Figure 6 - A mini crucible.

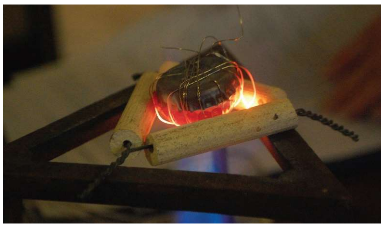

Figure 7 - Magnesium in a bottle-top crucible.

References
[1] http://microchemuk.weebly.com/.
[2] http://www.sserc.org.uk/index.php/chemistry-resources/microscale-chemistry.