SSERC *Bulletin*

Ideas and inspiration supporting science and technology for all Local Authorities

No. 257 - Winter 2016

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Effective demonstrations

Demonstrations to support learning and teaching in science and technology have been used over many years (see for example Figure 1) [1]. An extensive literature has been developed to provide support for those wishing to increase the number, variety and complexity of demonstrations which we might utilise.

Those wishing to use demonstrations to support delivery of the curriculum are well served especially if your subject areas cover the physical sciences. So, for example, a recent search of Amazon.co.uk using the terms 'chemistry demonstrations' or 'physics demonstrations' yielded 470 and 887 'hits' respectively and whilst not all of the titles are relevant, and there are a number of duplicate entries, there is plenty of scope to find suitable support materials. Those of us working in biological sciences are less-well served - the corresponding number of hits for 'biology demonstrations' was 207 (including a significant number related to the animal rights movement).

When considering using demonstrations as part of your learning and teaching strategy a number of questions arise including, but necessarily limited to:

- Why might one wish to incorporate them?
- What do you need to do or have in place to make them effective learning tools?
- Which ones should be included? (This is sometimes also referred to which ones are 'my favourites'...?).

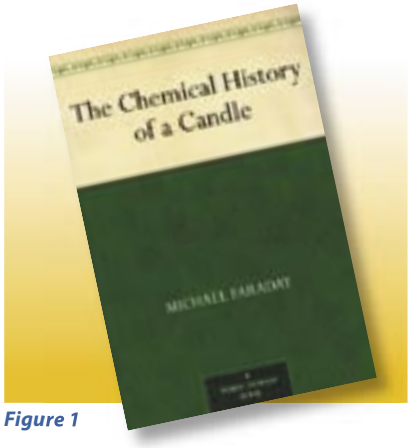

Figure 1

We have asked delegate on a number of recent SSERC courses why they might wish to use demonstrations as part of their learning and teaching strategies. As one might expect we received a number of responses including:

- Engagement/inspiration/drama/fun/reward/fascination.
- Stimulate thinking/encourage discussion.
- Where the activity might be dangerous or difficult or the costs of materials was prohibitive for the whole class to do the activity.
- Time constraints mean that 'doing the demonstration is more convenient'.
- To show good practice.

A number of teachers remarked that activities which might previously have been undertaken as class practical sessions were being shown increasingly as demonstrations in an effort to keep down costs.

In making demonstrations effective learning tools there are a variety of key aspects which should be considered. Some 40 years Wesley Smith identified six characteristics of effective demonstrations and his points are as valid today as they were at that time [2]:

1) **Demonstrations must be timely and appropriate.** Demonstrations should be done to meet a specific educational objective. Demonstrations for their own sake have limited effectiveness.

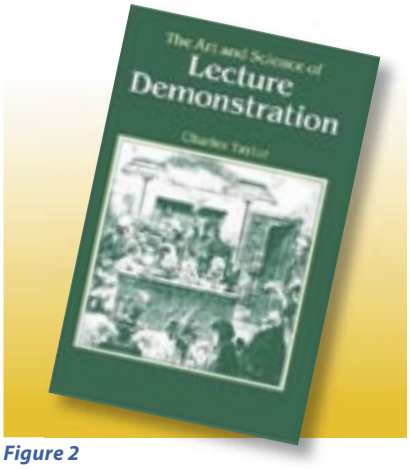

Figure 2

2) **Demonstrations must be well-prepared and rehearsed.** To ensure success you need to be thoroughly prepared. All necessary materials and equipment should be collected well in advance and you should rehearse the entire demonstration from start to finish.
3) **Demonstrations must be visible and large scale.** A demonstration can help only those students who experience it.
4) **Demonstrations must be simple and uncluttered.** A common source of distraction is clutter surrounding the demonstration itself.
5) **Demonstrations must be direct and lively.** Action is an important part of a good demonstration; it is the very ingredient that makes demonstrations such efficient attention-grabbers.

in teaching

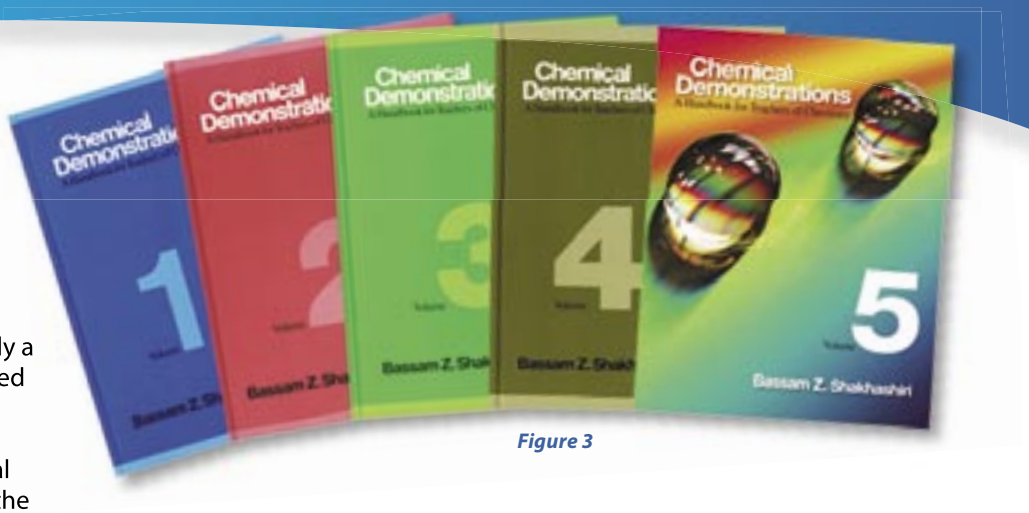

Figure 3

6) **Demonstrations must be dramatic and striking.** Usually a demonstration can be improved by its mode of presentation.

For those interested in a historical context, Charles Taylor explores the origins of lecture demonstration and its development to the present day, emphasizing the underlying principles and the lessons to be learned. With examples from Michael Faraday to Lawrence Bragg, Taylor's book (Figure 2) contains much interesting and useful information.

In terms of favourite demonstrations that is, of course, often down to personal choice. When asking teachers from our courses which ones they like to use the following often appear:

- *methane bubbles*
- *hydrogen balloons*
- *Young's modulus*
- *alkali metals*
- *eye dissection*
- *lycopodium powder/ explosions*
- *elephant's toothpaste*
- *screaming jelly baby*
- *range of hearing*
- *Van der Graaf*
- *water rocket*
- *tea bag rocket*
- *whoosh bottle*
- *heart & lung dissection*
- *thermite reaction*
- *chemiluminescence*
- *iodine clock*
- *Ruben's Tube*

In our judgement the best source of demonstrations for the chemical sciences are the series of books edited by Shakhashiri (Figure 3).

Each demonstration has a number of sections including:

- list of materials
- procedure
- list of hazards
- storage and disposal
- reference material

For those of you teaching physics there are a wide range of sources available to you. Two texts which we would recommend are the books by Sprott and Ehrlich shown in Figure 4.

Each text contains a wide range and variety of demonstrations to enliven your teaching.

As noted previously the biological sciences community is somewhat the 'poor relation' when searching for suitable resources to support the use of demonstrations in learning and teaching. That said there are, despite its title, a number of well-explained and detailed examples in Volume 5 of the Shakhashiri series. Other sources worth looking at include the *Journal of Chemical Education and School Science Review.*

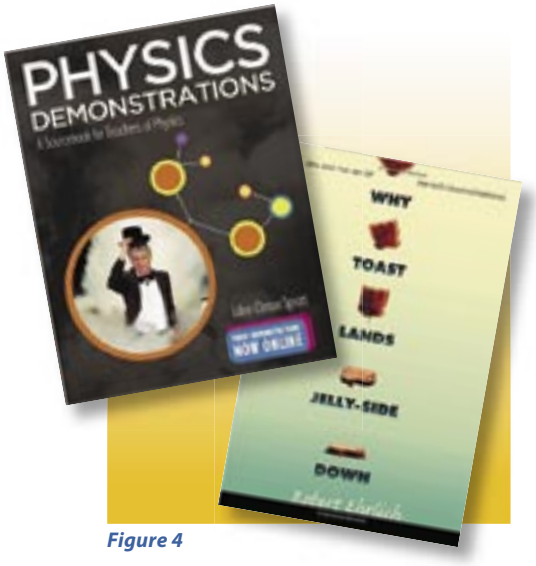

Figure 4

Professional development at SSERC

Within SSERC we are fortunate in that we have been able to obtain funding from the National STEM Learning Centre, through its ENTHUSE Awards scheme, to provide a course for teachers and technicians on 'Effective Demonstrations in Teaching'. For those in Local Authority schools or colleges the direct costs of the course are offset by an ENTHUSE Award.

As well as the course fee being met through this grant we offer a suite of resources which you can take back with you to enhance your teaching. Further details are available via the Chemistry CPD pages of the SSERC website [3]. Part One of the next course is scheduled for March 2017.

References

[1] Faraday, M. (2009) The Chemical History of a Candle: A Course of Lectures Delivered before a Juvenile Audience at the Royal Institution, Book Jungle, ISBN 1438510381.
[2] Smith, W. quoted in Shakhashiri, B.Z. (1983), *Chemical Demonstrations: A Handbook for Teachers of Chemistry Volume 1*, University of Wisconsin Press, Madison.
[3] http://www.sserc.org.uk/index.php/cpd-sserc/chemistry-courses-sserc.

Near as makes no difference?

Volumetric analysis is one of the bedrocks of quantitative chemistry and remains an important technique for students of chemistry to master. In a school setting at least, it is synonymous with titration which in turn is a technique that has changed little in over a century. But are we, perhaps, focussing too much on the process and not enough on what we are trying to measure?

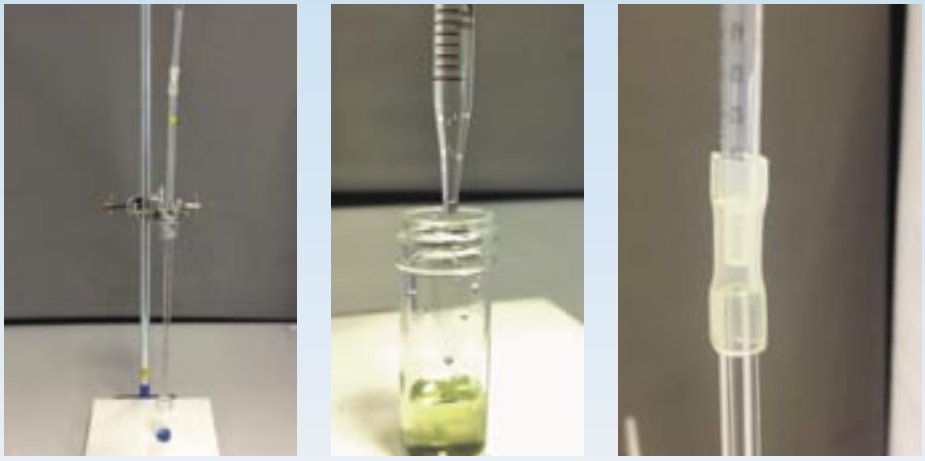

Figure 1 *- Microscale titration using a graduated pipette.*

The traditional titration is a good technique and an important one for students to master. It does, however, have a few drawbacks; burettes are relatively expensive and fragile and titrations use quite large quantities of solutions.

In this article, we are going to show a couple of alternatives to the traditional titration and evaluate their convenience and accuracy.

1) Microscale titration using a graduated pipette

This is simply a scaled down version of a 'normal' titration. A 1 cm^3 or 2 cm^3 pipette takes the place of the burette and the flask is replaced with a small vial or test tube.

A syringe is fixed to the top of the pipette by means of a short length of silicone tubing and this can be used to draw up the titrant into the barrel of the pipette. The syringe can then be used to dispense the titrant drop by drop by applying gentle pressure (Figure 1).

The method is simple and reliable and easy to master. It is also similar enough to a 'normal' titration to be familiar.

2) Microscale titration using a Pasteur pipette

In this case, the burette is replaced with a Pasteur pipette that dispenses the titrant drop by drop (Figure 2). A normal 1 cm^3 pipette will give on average 25 drops per cm^3, meaning each has a volume of 0.04 cm^3. Better results can be obtained by using fine tipped pipettes; these produce smaller drops, about 50 to the cm^3, giving each one a volume of about 0.02 cm^3.

It is possible to simply hold the pipette in your hand but there is a tendency to change the angle at which you are holding it and this can affect the size of the drops. A much better method, in many ways, is to hold the bulb of the pipette in a laboratory clamp. Turning the screw to tighten the jaws of the

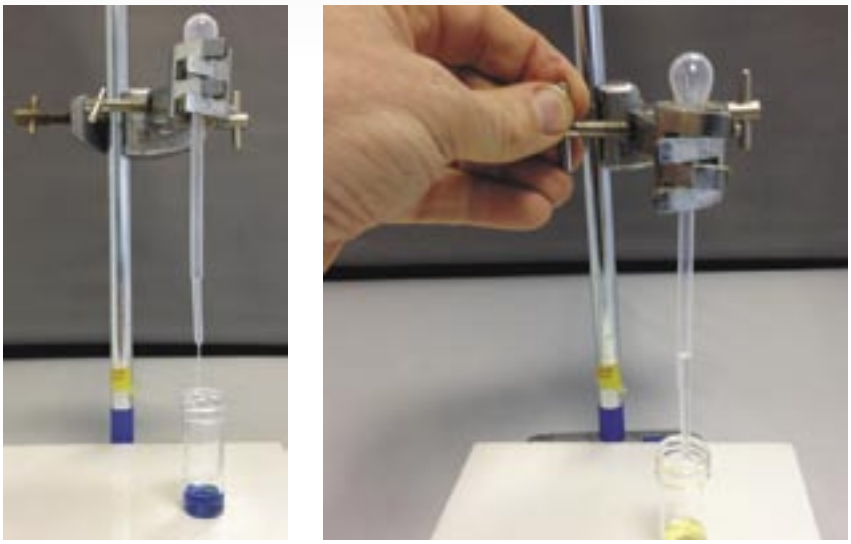

Figure 2 *- Microscale titration using a Pasteur pipette.*

Figure 3 *- Counting drops.*

clam slowly squeezes the bulb and expels the titrant slowly enough that you have a high level of control.

Unlike a burette, these pipettes have no scale on the barrel so we need to find other methods to determine the volume. There are two ways:

a) Counting drops

With a reasonable amount of care, the pipettes will dispense drops of a uniform size (0.04 or 0.02 cm^3). So a simple count of the number of drops can easily be converted into volume.

This is fine if your volume is relatively small compared to the drop size but if not you will end up having to count too high and will end up frustrated when you lose count. This problem can be avoided if you take an entirely different approach that might seem odd when talking about volumetric analysis …

b) Measuring the mass

Most aqueous solutions, unless they are quite concentrated, have a density very close to that of water. That makes it easy to simply take the density as 1 g/cm^3 and to measure the mass as a proxy for the volume.

The advantage of this approach is that it is much easier to measure mass accurately than volume. It is true that normal laboratory balances are quite expensive and so this would not solve the issue of expense associated with burettes but pocket 0.01 g balances can be bought for around £5.00 now and these, while not perhaps as robust as laboratory balances are, in our experience, just as accurate.

Accuracy

The important thing here is to find what is the limiting factor.

Reading accuracy

Burette - the limiting factor here is the accuracy with which it is possible to read the scale. Most burettes have markings every 0.1 cm^3. It is, with care, perhaps possible to read half graduations. If we assume so then that means we have an accuracy of 0.05 cm^3. In fact, the drop size from a burette is around 0.05 - 0.06 cm^3 so this is indeed the level of accuracy.

Pipette - the markings on a 1 cm^3 pipette are every 0.01 cm^3 and it is possible to read intermediate values as with a burette. However, the drops from pipettes have a volume of 0.04 cm^3 so this is the minimum level of accuracy.

Pasteur pipette - when dealing with drops from a pipette, the fact that a balance can measure to 0.01 cm^3 is neither here nor there as the minimum drop side is either 0.04 or 0.02 cm^3.

Error

The accuracy to which it is possible to take a reading is only part of the story though. The titre volume plays a part too.

If we take a standard titration as about 25 cm^3 then reading to 0.1 cm^3. This gives a theoretical accuracy of ± 0.4%.

For the microscale titrations, let us assume a titre of 1 cm^3. In this case, a drop size of 0.04 cm^3 gives an accuracy of ± 2% using fine-tipped pipettes. Increasing the volume to 2 cm^3 improves the accuracy to ± 1%.

This is not quite as good but certainly reasonably close.

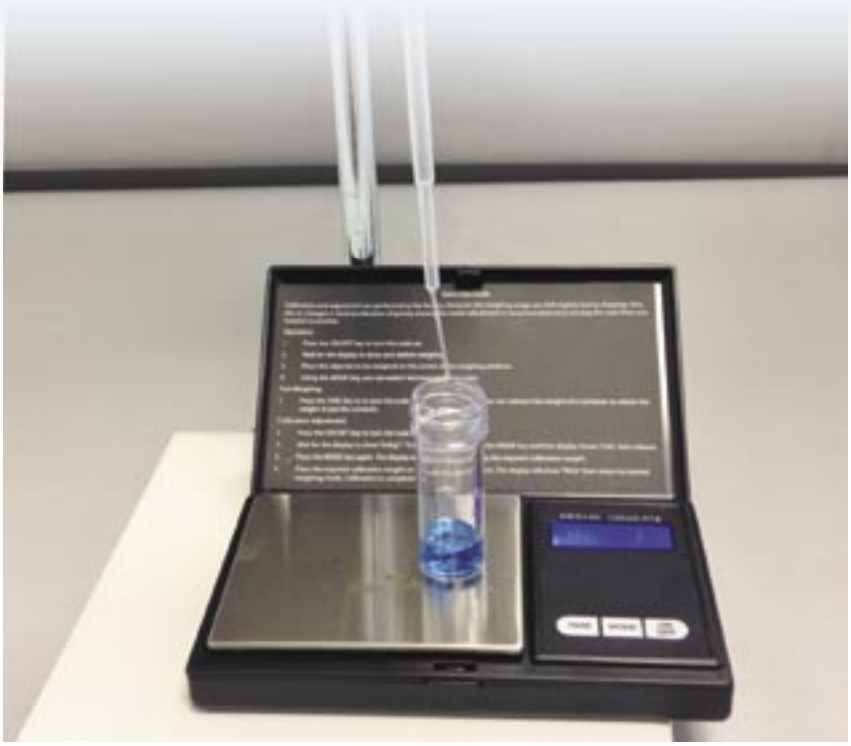

Figure 3 *- Measuring the mass.*

TITRATION 1 - conventional titration						
vol of alkali	[alkali]	moles	vol of acid		[acid]	
20	0.1	0.002	18.9		0.1058	**Molarity = 0.106**
20	0.1	0.002	18.9		0.1058	
20	0.1	0.002	18.8		0.1063	
TITRATION 2 - 1 cm³ pipette (with syringe adaptor)						
vol of alkali	[alkali]	moles	vol of acid		[acid]	
1	0.1	0.0001	0.96		0.1041	**Molarity = 0.104**
1	0.1	0.0001	0.95		0.1053	
1	0.1	0.0001	0.96		0.1042	
TITRATION 3 - 2 cm³ pipette (with syringe adaptor)						
vol of alkali	[alkali]	moles	vol of acid		[acid]	
2	0.1	0.0002	1.85		0.1081	**Molarity = 0.108**
2	0.1	0.0002	1.85		0.1081	
2	0.1	0.0002	1.87		0.1069	
TITRATION 4 - drops from 1 cm³ fine tip pipette by drops						
vol of alkali	[alkali]	moles	drops of acid	vol of acid	[acid]	
1	0.1	0.0001	50	0.96	0.1041	**Molarity = 0.103**
1	0.1	0.0001	51	0.98	0.1021	
1	0.1	0.0001	51	0.98	0.1021	
TITRATION 5 - drops from 1 cm³ fine tip pipette by mass						
mass of alkali	[alkali]	moles	mass of acid		[acid]	
0.97	0.1	0.000097	0.91		0.1066	**Molarity = 0.108**
0.99	0.1	0.000099	0.92		0.1076	
0.98	0.1	0.000098	0.90		0.1088	

Table 1 *- Series of titrations.*

How good is good enough?

When considering the accuracy of a technique, however, we need to consider how accurate we need to be in each case. If we needed to be as accurate as is possible in every case, we would make up every solution in volumetric flasks using a 3 (or more) place balance. While there are times when this level of care is absolutely required, there are plenty of occasions where it is not. So the question is, is the level of accuracy of these simpler techniques sufficient for general usage or not?

Let us look at a real life example. Table 1 shows some results of a series of titrations of 0.1 M sodium hydroxide with 0.1 M hydrochloric acid. Neither of these was standardised but that does not matter for the purposes of our calculations.

We have assumed that the molarity of the NaOH is exactly 0.1 M and have used the titre to calculate the concentration of the HCl solution (see Table 1).

Conclusions

As you can see from the data above. These simple methods can give pretty accurate results. A molarity of 0.104 or 0.107 compared to 0.106 is, in our view, certainly good enough. Even the least accurate method, counting the drops, gives 0.102 M which is fine for most purposes - in fact in most cases the accuracy with which the solutions are made up is likely to have a greater effect.

Where accuracy matters, in Advanced Higher projects for instance, then of course the standard method should be used. It is also important as a part of their preparation for exams that pupils are familiar with the apparatus and techniques of a classical titration.

However, where apparatus is in short supply or where expensive reagents are involved, in argentometric titrations for instance, the microscale approaches detailed above give perfectly adequate results and allow quantitative chemistry to be done much more easily and by every individual in the class rather than as part of a group.

Concept Cartoons - meet the author

We are delighted to announce that Stuart Naylor, one of the principal authors of Science Concept Cartoons Set 2, is due to deliver a 'twilight' professional development session at SSERC on Monday 6th February 2017.

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Aimed at learners in the age range 10-16, this new resource for Chemistry, Biology and Physics covers topics including earth and space, living things and their environments, physical and chemical changes.

Concept Cartoons are designed to introduce science concepts in everyday settings. Each character has a different opinion about science being discussed. All of the possible answers are plausible and highlight common learner misconceptions. Learners are invited to join in with the discussion happening in the science Concept Cartoon.

The book and CD of Science Concept Cartoons Set 2 both contain 156 Concept Cartoons covering the main areas of science. Background text, written in pupil-friendly language, is available for each Concept Cartoon.

Fee

The fee for the course is £135 to include a copy of the book and CD of Science Concept Cartoons Set 2 as well as a site license meaning that all teachers in a school can use the resource in their teaching. Light refreshments will be provided on arrival.

Applications

Please go on-line (http://tinyurl.com/SSERC-new-online-app) to book a place (closing date for applications is 25th January 2017).

Stuart Naylor.

SSERC conference

(2nd December 2016)

Our annual one-day conference will take place on Friday 2nd December 2016 at Carnegie Conference Centre, Dunfermline.

We are delighted to announce that Professor Sheila Rowan, Chief Scientific Adviser for Scotland, has agreed to give the Keynote presentation at the Conference.

The conference is offered free of charge to teachers, technicians, Health and Safety officers and any other interested personnel from a Local Authority or SSERC member organisation. This year we will be offering a range of workshops which highlight safe, reliable and relevant resources for teaching and learning. During these workshops delegates will have the opportunity to try out SSERC developed materials that support both *CfE* and new national qualifications.

Further details, including a draft programme and registration details, are available from http://www.sserc.org.uk/index.php/cpd-sserc/conferences/4002-sserc-conference-2016.

Modelling LIGO with microwaves

LIGO, the Laser Interferometer Gravitational-Wave Observatory, uses a Michelson Interferometer set-up to detect tiny movements of a mirror caused by space stretching when a gravitational wave passes. Whereas LIGO depends on the interference of laser light, our version uses microwaves of wavelength 2.8 cm. Figure 1 shows a photograph of the assembled apparatus and Figure 2 the layout.

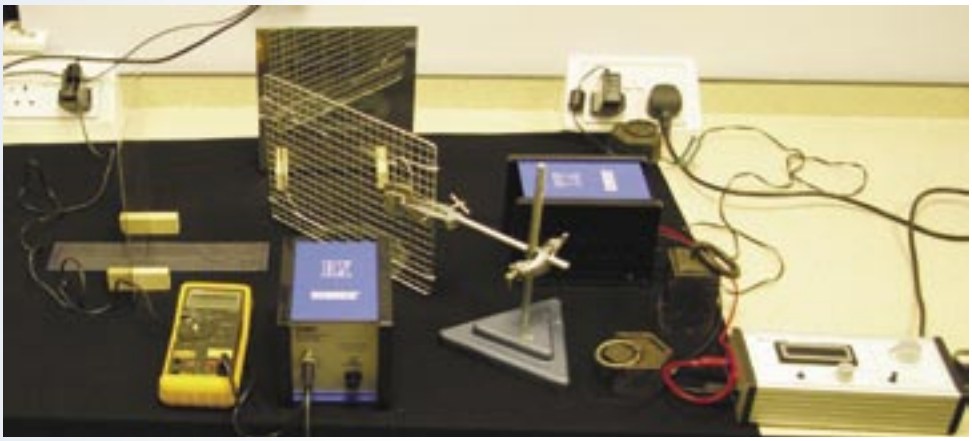

Figure 1 *- Microwave Michelson Interferometer.*

The equipment used is standard school microwave kit apart from a beam splitter and (optional) a sheet of Lycra®. The microwave transmitter and receiver are placed at right angles to one another. A metal reflector is placed around 50 cm in front of each. The beam splitter - we found that a barbecue grill with a 12 mm mesh was ideal - is placed at an angle of 45 degrees to the transmitter and receiver as shown in figure 2. A voltmeter is connected to the output of the receiver, giving a reading that is proportional to microwave intensity.

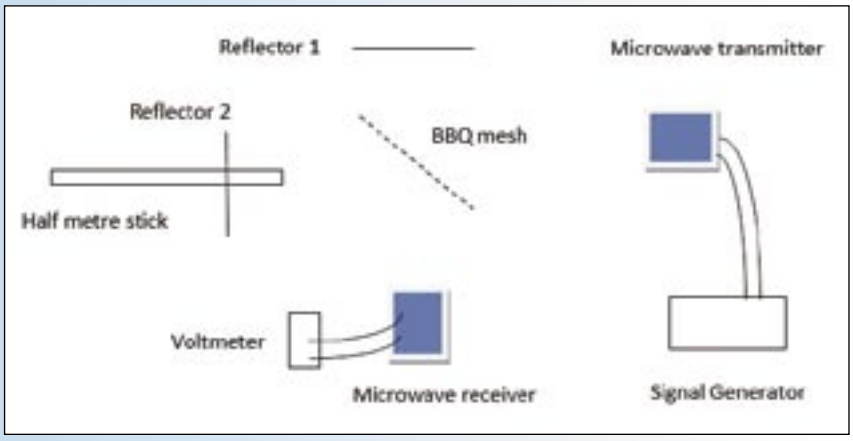

Figure 2 *- Diagram of layout.*

Figure 3 helps us to understand how interference occurs.

Some of the microwave radiation - ideally 50% - passes through the beam splitter, reflects from reflector 2 then reflects off the mesh and travels towards the receiver (blue path). The rest of the radiation is reflected by the beam splitter, strikes reflector 1 and is then reflected towards the receiver (red path). Interference then occurs at the receiver. If we move one of the reflectors and plot the voltmeter reading versus displacement, a series of maxima and minima can be found. Maxima (or minima) should be half a wavelength apart. An alternative approach is to determine the position of maxima using a half metre stick. Call the first maximum m=1 and plot y versus m where y is the position of the reflector. The gradient should equal one half wavelength (Figure 4). We suggest that you experiment with the relative positions of the reflectors to try to get as low minimum values as possible.

To model LIGO, we mounted our equipment on a sheet of Lycra, secured at the transmitter end using weights. We then positioned the reflector such that we had a minimum reading on our meter. The Lycra represents space, so a gravitational wave can be simulated by carefully stretching then relaxing the material. When this was done, we observed the reading on the meter rise and fall. Our equipment allowed the transmitted wave to be modulated and the receiver had a built in speaker. By modulating the microwaves using an audio frequency, we could hear the sound level rise and fall as the "wave" passed. We felt this was a satisfactory analogue to the "chirp" heard by the LIGO team when they detected their first wave.

We think that microwave Michelson Interferometer experiments could form part of an Advanced Higher project. In a future issue we hope to write about finding the refractive index of materials using the apparatus. Initial results are encouraging. We are sure, too, that many physics teachers share our excitement in the discovery of gravitational waves. Here is what we hope is an effective way to explain what's going on to your senior phase students.

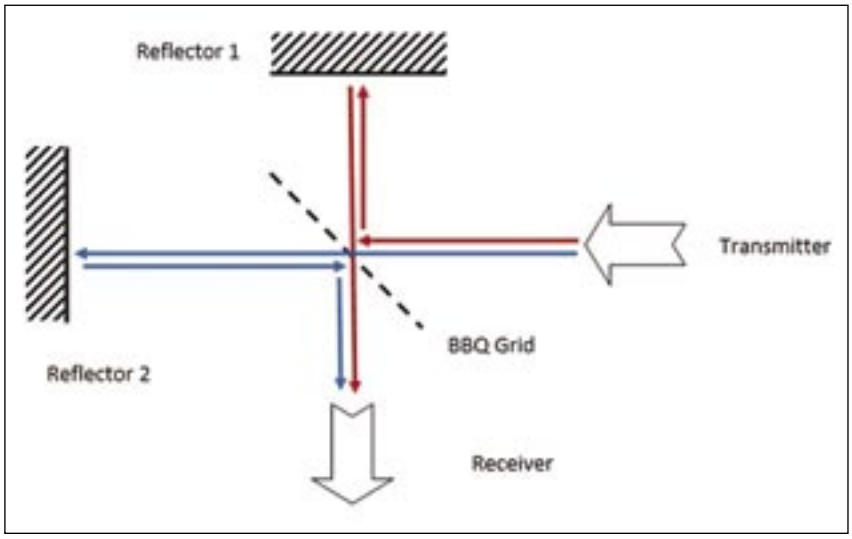

Figure 3 *- Beam paths in the interferometer.*

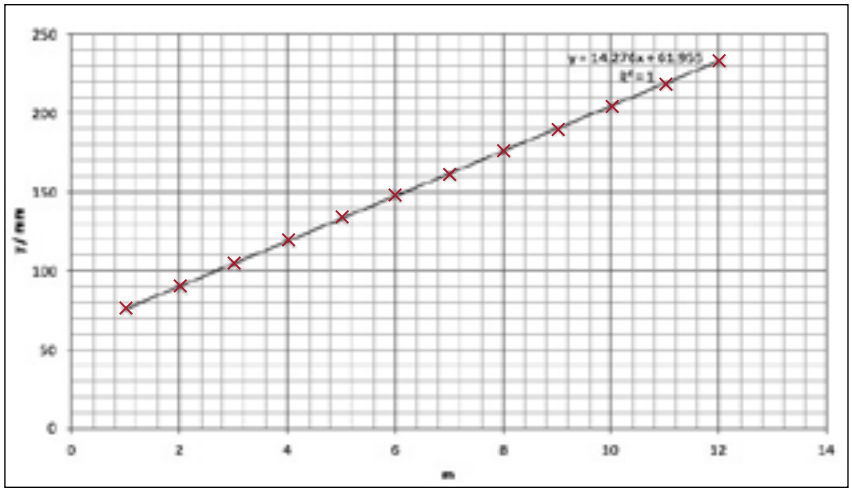

Figure 4 *- graph showing position of consecutive maxima/minima.*

STEMEC report

STEMEC (The Science, Technology, Engineering and Mathematics Committee) has recently published its final report [1].

In their conclusions, STEMEC observe:

Scottish STEM education stands on a strong base and has much to be proud of but it needs further support and development. Central to that is transparent, accountable education administration delivering linked, national strategies that focusses on the support of a teacher led profession that integrates all aspects from research to assessment but at all times aimed at providing pupils with a rounded education that allows them to both gain from and contribute to society.

In publishing the report STEMEC has made a series of 43 recommendations to government covering:

- Administration of Education
- Women in STEM
- Initial Teacher Education
- Primary Science
- Effective Career Long Professional Development and Professional Learning Communities
- Interdisciplinary Learning (IDL)
- Additional Barriers to Success

Reference

[1] The full report can be accessed at http://www.gov.scot/Topics/Education/Schools/curriculum/STEM/STEMEC/Report.

STEM insight

STEM LEARNING

PROJECT ENTHUSE

The STEM Insight programme offers you a valuable chance to experience STEM-related work in industrial or academic settings, and learn more about diverse career paths and opportunities.

Insight into industry

During a placement, develop your knowledge of STEM careers and routes for your students to progress into STEM-related employment. Work with world-leading employers across a range of STEM industries including engineering, medical, manufacturing, computing and many more.

Insight into university

Spend time in a leading UK university and learn about the latest cutting edge research in your field. Support your students as they apply and make the transition from school to university.

Supported by a tailored package of face-to-face and online CPD that is bursary supported, you can:

- Enrich your teaching of the STEM curriculum by linking to careers.
- Help your students make better informed choices about their futures.
- Make long-term links with employers and universities.
- Receive the opportunity to build a network of industry and university experts who can share knowledge across schools and colleges.
- Respond to the nationwide drive to improve careers education.

Get involved - www.stem.org.uk/stem-insight

SSERC professional development courses

Our professional development courses range from twilight events, day-courses through to residential meetings lasting up to 6 days in total. Our curriculum coverage spans both primary and secondary sectors and we offer events for teachers as part of their career long professional learning, newly qualified teachers and technicians. Many of our events receive funding from the ENTHUSE awards scheme or the Scottish Government.

COURSE NAME	RESIDENTIAL?	DATES	CLOSING DATE	SECTOR
Supporting STEM	Yes	18-19 November 2016 (part 1) 17-18 March 2017 (part 2)	31 October 2016	Primary
Working with Radioactive sources (Teachers and Technicians)	No	29 November	28 October 2016	Secondary
SSERC Conference	No	2 December	4 November 2016	ALL
Secondary Probationers 2017	Yes	7-8 February 2017 (part 1) 6-7 June 2017 (part 2)	25 November 2016	Secondary
H&S Risk Assessment	No	16 January 2017	2 December 2016	Secondary
Safe Use of Fixed Workshop Machinery	No	20-21 February 2017	16 December 2016	Secondary
Safe Use of Fixed Workshop Machinery	No	29-30 March 2017	16 December 2016	Secondary
Introductory Physics	No	22-23 February 2017	16 December 2016	Secondary
Biology RCUK Day Roslin Institute	No	14 February 2017	12 January 2017	Secondary
Effective Demonstrations in Teaching	Yes	10-11 March 2017 (part 1) 22 May 2017 (part 2)	22 January 2017	Secondary
Concept Cartoons (Secondary)	No	6 February 2017	25 January 2017	Secondary
Hot Metal 1 Cohort 1	No	24-26 April 2017	24 February 2017	Secondary
Hot Metal 1 Cohort 2	No	26-28 April 2017	24 February 2017	Secondary
Hot Metal 1 (Technicians)	No	26 April 2017	24 February 2017	Secondary
Hot Metal 1 (Technicians)	No	10 May 2017	24 February 2017	Secondary
Hot Metal 1 Cohort 3	No	8-10 May 2017	24 February 2017	Secondary
Hot Metal 1 Cohort 4	No	10-12 May 2017	24 February 2017	Secondary
Physics Summer School	Yes	24-27 May 2017	21 April 2017	Secondary
Chemistry Summer School	Yes	14-16 June 2017	8 May 2017	Secondary
Biology Summer School	Yes	27-29 June 2017	26 May 2017	Secondary
Primary Summer School	Yes	4-5 July 2017	31 May 2017	Primary

Cheese please!

A limiting factor in many biology experiments is finding a reliable end point in a practical investigation or experiment. One such practical activity involves the milk clotting time associated with cheese making.

There are several steps in the manufacture of cheese. First, the milk is pasteurised to kill most of the bacteria, then other bacteria are added to convert the milk sugar (lactose) into lactic acid. Enzymes are added to clot the milk proteins.

Rennet is a mixture of enzymes produced in the stomachs of some animals. Chymosin, the key component of rennet, is a protease enzyme that curdles the casein in milk helping young mammals to digest their mother's milk. Chymosin can also be used to separate milk into solid curds used for cheese making, and liquid whey (Figure 1). In addition to chymosin, rennet contains other important enzymes such as pepsin. Originally the rennet used for cheese making came from the stomachs of young mammals such as calves.

Some people find it unacceptable to eat products from animals and alternative sources of milk clotting enzymes have been developed. Some fungi produce enzymes which clot milk proteins. These fungi are grown in large quantities in fermenters and the enzymes are then extracted.

With the development of genetic engineering, it is now possible to isolate the rennet coding genes from animal stomachs and insert them into certain bacteria, fungi, or yeasts making them produce chymosin during fermentation. The genetically modified microorganism is killed after fermentation and chymosin is isolated from the fermentation broth. This means that the fermentation-produced chymosin used by cheese producers does not contain any GM component or ingredient.

Determining the clotting time of the milk after the rennet is added has long been a part of many suggested biology investigations but it has often been difficult (and messy!) to accurately determine the exact clotting point.

The procedure described in this article is very simple to carry out and gives an accurate clotting time. The method involves placing a microscope slide into the clotting mixture until such time that the clots can be seen clearly on the slide.

Method

The original investigation can be found on the University of Guelph website [1] and further information such as a teacher/technical guide, help cards and an investigation sheet can be found on the SSERC website [2].

The basic method is summarised as:

1) Place 20 cm^3 of milk into a small beaker and measure the pH.
2) Add 2 cm^3 of 0.02% calcium chloride solution.
3) Stir the beaker and warm to 30°C.
4) Add 0.2 cm^3 of rennet enzyme, stir and measure the pH.
5) Every 30 s dip a clean microscope slide into the milk and record when flecks of curd appear on the slide (the clotting time).
6) Record the pH .

This method could form the basis of many different investigations where learners could vary:

- the type of rennet used;
- the starting pH of the production mixture;
- the temperature of the milk;
- the type of milk used;
- the concentration of calcium chloride used in the production mixture;

Figure 1 *- The whey begins to seperate from the curds.*

- the quantity of salt which is added to the production mixture (common salt is added as a regular component of cheese and whilst the standard protocol above does not include such salt it could be added as an additional variable).

Other resources

There are a number of on-line resources which one might use to support learning and teaching in respect of this topic [3].

Curriculum links

This milk clotting practical can easily be explored at different levels within the curriculum. For example:

- National 4: Cell Biology: 4. Properties of enzymes and use in industries; Carry out experiments with rennet. Make cheese/visit cheese factory. Investigate the history and ethics of rennet.

Figure 2 *- After a certain time the clots can be seen clearly on the microscope slide.*

- *CfE* Higher Biology also has an outcome which fits well with this practical activity: CELL BIOLOGY: 3. Metabolism in microorganisms:
  - Recombinant DNA technology.
  - Use of recombinant yeast cells.
  - Ethical considerations in the use of microorganisms, hazards and control of risks.

We have gathered a group of relevant resources together on the SSERC website [4].

In addition to the practical activity and investigation, a discussion activity [4] has been developed to complement the practical aspect and to explore some of the moral and ethical issues associated with the use of GM products. Discussion cards are available for each type of rennet and learners take on the role of the scientist, the salesperson or the consumer and have to consider the pros and cons of each type of rennet as shown in the example on the left (Figure 3).

Health & safety

There are no particular safety concerns associated with this activity although it should be emphasised that the cheese produced under the conditions outlined here is not suitable for human consumption.

Calf Rennet

Background Rennet is found in the stomachs of calves. It contains enzymes which break down the protein in milk to make it digestible to the animal. Calf rennet contains 2 enzymes rennin (chymosin) and pepsin. Chymosin is the enzyme which is most important in cheese making. The enzyme coagulates the milk separating it into curds and whey. The lining of calves stomachs is processed to produce this product.	**Scientist** Rennet is obtained from the abomasum (fourth stomach) of newly born calves. The rennet is usually obtained from calves which are being used for veal production. Adult cattle do not contain sufficient quantities of the rennet. The chymosin is extracted by washing and drying the stomach lining. The lining is then cut into small pieces and macerated in a solution of boric acid or brine at 30°C for 4-5 days. Since 1837 calf rennet has been extracted in this way and sold to the cheese making industry.
Salesperson -Here are some of the advantages which our product has:- -Calf rennet was the first ever product which allowed cheese to be made. -Cheese manufacturers are used to it and are happy with the type of cheese which it makes. -No genetic engineering has been used to produce calf rennet. -It is the natural enzyme doing the same job in the calves stomach as it does in the cheese factory.	**Consumer**- I object to all of the new strange products which have come onto the market. I want to eat good old fashioned cheese which is made the good old fashioned way. The calves are going to be killed anyway so I think that it is good to use the stomachs rather than letting them go to waste. I think that we should support the British farmers and the British farm products such as calf rennet. Lots of people do not want vegetarian products. Human beings evolved to eat meat and most of us want to stay that way.

Figure 3

References

[1] University of Guelph, https://www.uoguelph.ca/foodscience/book-page/rennet-activity.

[2] http://www.sserc.org.uk/index.php/biology-2/biology-resources/biology-national-4149/n4-cell-biology/3372-properties-of-enzymes-and-use-in-industries2.

[3] An overview of the cheese making process can be found at www.rsc.org/chemistryworld/2013/11/cheese-chemistry and a suitable film showing the cheese making process can be found at www.youtube.com/watch?v=RIfRnjf1CCM.

[4] http://www.sserc.org.uk/index.php/biology-2/biology-resources/biology-national-4/n5-cell-biology/3402-proteins-and-enzymes.

'Bacteria Farm' - safety alert!

Safety in Microbiology - A Code of Practice for Scottish Schools and Colleges.

1.1 All microbiological materials, cultures, media, environmental samples etc. from whatever source should be treated as though they were a potential source of pathogens.

'Bacteria Farm' is the name of a hands-on *Artec Science Series* kit (Science Series 196415) which until recently was for sale to schools via the *Scientific and Chemical* Science Education Resources Catalogue (September 2016 - September 2017), catalogue number HLB010040, for around £6.00 [1]. The resource is available from other suppliers including, for example, Amazon [2].

SSERC was alerted to the existence of the kit by a school technician who, while flicking through the catalogue, saw and recognised the inherent hazards associated with the activities mentioned in the product description which reads, *"Try cultivating different kinds of bacteria. You will be surprised to see how many kinds of bacteria are surrounding us in our everyday lives! Place a clean and dirty finger in different cells, use a swab to take a sample of bacteria from your toilet, shoe, dustbin, mouth or nose and see the bacteria grow!"* [3].

The 'study guide' that accompanies the kit, which is aimed at children 'Age 6+', outlines procedures and activities that anyone with even a passing familiarity with SSERC's *Safety in Microbiology: A Code of Practice for Scottish Schools and Colleges* [4] would find alarming. However, after brief correspondence with SSERC, Scientific and Chemical's marketing team commendably withdrew the product from their catalogue and destroyed their stock of the kits. It is reassuring to know that no kits have been purchased from *Scientific and Chemical* by Scottish schools.

It should be noted, however, that other providers, for example Amazon [2], do have the 'Bacteria Farm' kit for sale. For this reason we thought it would be worthwhile highlighting some of the potential hazards associated with 'Bacteria Farm'.

Safety in Microbiology: A Code of Practice for Scottish Schools and Colleges (SSERC, 2012) is a set of risk assessed guidelines that teachers and technicians involved in delivering microbiology in Scottish local authority schools and SSERC member colleges and schools follow. In addition, personnel (technicians or teachers) trained to 'Level 3' in microbiological safety support the delivery of this aspect of the curriculum. Therefore, appropriately trained staff prepare sterile media and ensure the safe disposal of inoculated cultures by autoclaving.

In our view none of the activities associated with 'Bacteria Farm' are suitable to be carried out in schools because any media prepared using the instructions and equipment supplied in the kit would not be sterile.

Furthermore, 'Bacteria Farm' suggests that children could take samples, from toilets, bins, noses etc., using swabs to collect the samples and inoculate the (non-sterile) culture medium in the 'cultivation plate' that comes with the kit. **Alarm bells!**

The *Code of Practice*, *Section 2.19*, *page 9*, states [4]:

*Samples from carefully chosen areas of the environment may be used, but only to inoculate sterile solid media. In particular, samples **must not** be taken for culture from:*

- *human or other animal body surfaces;*
- *body fluids and secretions;*
- *animal cages or aquaria;*
- *lavatories;*
- *faecal material;*
- *poultry, eggs or areas which have been in contact with poultry;*
- *meat or meat products;*
- *dead animals;*
- *milk which has not been pasteurised;*
- *soft, unpasteurised, cheeses;*
- *water sources likely to contain faecal or sewage pollution;*
- *soil fertilised by animal manure or fouled by animal faeces;*
- *mud (e.g. from a pond or field).*

The problem is of course that the growth medium provides ideal growing conditions for microorganisms and by swabbing, or sampling, any of these areas and then inoculating a growth medium you may well culture human pathogens.

'Bacteria Farm' *- a hands-on Artec Science Series kit.*

In secondary schools, if students were to swab suitable areas, laboratory work surfaces for example, on to sterile media in Petri dishes, the resulting cultures would be disposed of by autoclaving carried out by a suitably trained person. Nowhere in the 'Bacteria Farm' study guide does it say how one might safely dispose of the 'cultivation plate' with its farm of unknown and potentially pathogenic organisms. The 'Bacteria Farm' study guide also advocates taping along the edge of the cultivation plate to seal it. Petri dishes containing inoculated media should never be sealed all the way round with tape as this excludes oxygen and thus encourages the growth of anaerobic organisms; these are more likely to be dangerously pathogenic than aerobic organisms.

There are several other issues with 'Bacteria Farm' we could mention, but suffice to say that, given the issues we have pointed out, 'Bacteria Farm' is an activity which should not be used in Scottish secondary schools. It is even more unsuitable for primary schools, where it is unlikely that there would be appropriately trained staff or suitable equipment such as autoclaves. The idea of young children and a supervising adult carrying out these activities at home unaware of the hazards is very worrying indeed.

SSERC has shared this information with CLEAPSS [5], the organisation that performs the equivalent health and safety role for schools in England, Wales and Northern Ireland.

Thank you to the technician who brought this matter to our attention and thank you to *Scientific and Chemical's* marketing and sales staff who responded so swiftly and decisively to SSERC's advice.

References

[1] Scientific and Chemical science education resources catalogue (September 2016 - September 2017), catalogue number HLB010040. Also available at http://education.scichem.com/Catalogue/Search.
[2] www.amazon.com.
[3] Scientific and Chemical science education resources catalogue (September 2016 - September 2017), page 139.
[4] Safety in Microbiology: A Code of Practice for Scottish Schools and Colleges, (SSERC, 2012). Also available from the SSERC website at http://www.sserc.org.uk/index.php/biology-2/health-a-safety-home151.
[5] CLEAPSS, www.cleapss.org.uk.

Topics in Safety - working with enzymes

The ASE Health and Safety Group (formerly the Safeguards in Science Committee) continues to revise the publication *Topics in Safety*. We understand that the task is now over halfway to completion and that good progress is being made.

In 2015 [1] we briefly discussed changes to the legislation that controls the way work with DNA is regulated and we highlighted that [2] revisions had been made to Topic 16 (Working with DNA).

Our colleagues at the National Centre for Biotechnology Education (NCBE) have recently alerted us to a new Topic in Safety 'Working with Enzymes' and this is available from the NCBE website [3]. This new document is a very useful source of health and safety advice about enzymes and their preparations.

Additionally the authors have sought, in our judgement very successfully, to provide a reference document with 'hints and tips' about the successful use of enzymes across school/college curricula.

Overall then, a very valuable and useful document - every department should have one!

References

[1] Working with DNA (2014), SSERC Bulletin **250**, 10-11.
[2] Topic 16: Working with DNA, *Topics in Safety*, ASE (2014), available at www.ncbe.reading.ac.uk/safety (accessed 22nd September 2016).
[3] Topic 20: Working with Enzymes, *Topics in Safety*, ASE (2016), available at www.ncbe.reading.ac.uk/safety (accessed 22nd September 2016).

The Night and Day reaction - a note of caution

We want to share a concern we have about the so-called Night and Day reaction. Within SSERC we have used this reaction for many years without incident; indeed we have routinely shared details of the reaction mixture with participants on a number of our courses. Looking through the literature we have been unable to find an original source although the recipe for this demonstration was originally provided to us by Dr Chris Mortimer at the University of Central Lancashire.

Figure 1 *- Earthrise from Apollo 8 (image by NASA).*

The name given to the reaction refers to the oscillating nature of the mixture once ignited. At intervals, a bright flame is produced during which period ignition of the Al powder is clearly visible. After a few seconds a small pale yellow flame is visible. The bright/pale cycle is repeated on a number of occasions. As such the reaction can be used to support the chemistry curriculum at a number of places.

We have, over the years, demonstrated this reaction without incident on several hundred occasions. However, in trying out the reaction recently rather than an oscillating reaction being established the reaction mixture, when ignited, underwent complete combustion within a very short period of time (considerably less than 1 second). The bright flash of light emitted and very rapid rate of the reaction lead us to conclude that we should no longer use this reaction mixture.

Please alert any of your colleagues who may have used this reaction to this cautionary note. We will, in due course publish details of the recipe for the reaction mixture once we have established how this change in reaction properties can be explained.

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