



# *SSERC* *Bulletin*

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Ideas and Inspiration supporting Science & Technology for all Local Authorities

*Food Dyes and Electrophoresis*

*Hair Laser*

*What's new on the equipment front?*

*Changes to radioactivity law*

*Secure your chemicals*

*Gas explosions caused by static electricity*

*Safety in micro- training to Level 3*

At least two of the Curriculum for Excellence outcomes for science [1] relate to studies of DNA which can be explored through practical work:

- I have extracted DNA and understand its function. I can express an informed view of the risks and benefits of DNA profiling [SCN 3-14b].
- I can use my understanding of how characteristics are inherited to solve simple genetic problems and relate this to my understanding of DNA, genes and chromosomes [SCN 4-14c].

Through the Science 3-18 website [2], SSERC provides access to a number of practical activities which can be used to support teaching and learning associated with the above outcomes. One of the most popular of these activities is the so-called 'Wonderful Wizardry of Finding a Gene' and details of the protocols have been published in previous issues of this Bulletin [3, 4]. In this scenario, which has its roots in the Harry Potter genre, students are asked to identify the wizard who has special powers. Briefly the experimental basis of the activity relies on the fact that mixtures of food dyes can be separated by electrophoresis using agar gels. The basic electrophoresis equipment required can be obtained from the *National Centre for Biotechnology Education (NCBE)* [5] but is probably already available in the majority of secondary schools throughout Scotland.



1. Blue: Brilliant Blue (E133, Food Blue 2 CI 42090)
2. Yellow: Quinoline yellow (E104, Food Yellow 13 CI 47005)  
Allura red (E129, Food Red 17 CI 16035)
3. Green: Quinoline yellow (E104, Food Yellow 13 CI 47005)  
Green S (E142, Food Green 4 CI 44090)
4. Black: Quinoline yellow (E104, Food Yellow 13 CI 47005)  
Green S (E142, Food Green 4 CI 44090)  
Carmiosine (Azorubine) (E122, Food Red 3 CI 14720)

**Table 1** - Dr Oetker Food Colours and list of colorants used.

Over the past few months members of the Biology Team within SSERC have received a number of enquiries indicating that the experiment has failed to work effectively. Here we wish to report our suggestions as to how one might overcome such problems. The protocols as originally written recommended the use of combinations of blue, black, yellow and green food colours from Dr Oetker or Supercook [6]. Table 1 lists the dyes used in the food colorants (information taken from labelling on sample bottles).

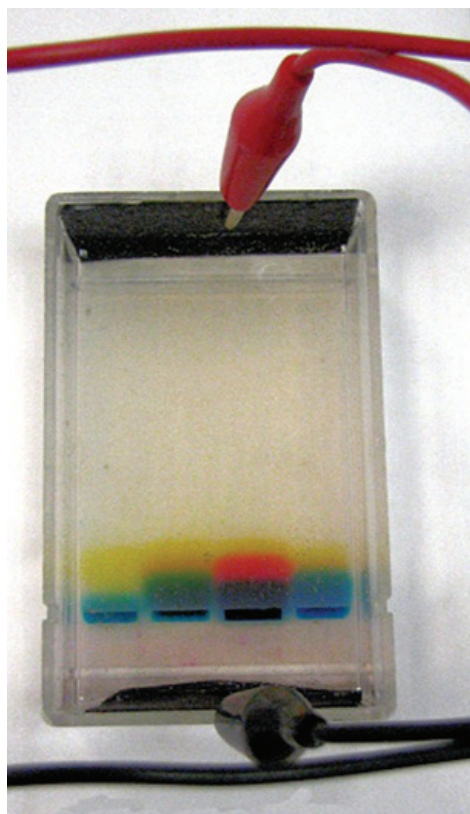
Dr Oetker's *Yellow Food Colouring* has recently been replaced with Dr Oetker's *Natural Yellow Food Colouring* and lutein is used in place of Quinoline yellow and Allura red [7]; Dr Oetker's *Black Food Colouring* has been replaced by Dr Oetker's *Natural Black Food Colouring* and carbon black is used in place of a combination of Carmiosine, Quinoline yellow and Green S [7]. On a recent visit to our local supermarket we did manage to obtain samples of Dr Oetker's *Black Food Colouring* rather than Dr Oetker's '*Natural Black Food Colouring*' although it is probably a matter of time before stocks of '*Black Food Colouring*' are depleted. The change in composition of the food colourings makes the Wizard Genes practical problematic in its current format.

The dyes in the original food colourings work well and so we have set about trying to identify alternative sources. To that end we note that all are available from FastColours [8] with the current cost being £6.00 + VAT for 10 g samples. It is possible, therefore, to prepare your own samples of concentrated colourings. While Blue and Green Food colourings continue to be produced by Dr Oetker there would be no need to buy samples of Brilliant Blue although if one wishes to follow the original protocol it would be necessary to purchase the other 4 dyes. We have done a series of trials using dyes from FastColours and we recommend that you prepare stock solutions in distilled water as follows:  
Green S - 0.2%; Brilliant blue - 0.2%; Allura red - 0.2%;  
Quinoline yellow - 0.4%; Carmiosine - 0.5%.

The dyes can be combined in the following ratios to simulate the original Dr Oetker food colourings:

- Black - Carmiosine, Quinoline yellow, Green S in the ratio 2:2:1
- Green - Quinoline yellow, Green S in the ratio 2:1
- Yellow - Quinoline yellow, Allura red in the ratio 2:1
- Blue - brilliant blue

In all other respects the protocols as published previously [3, 4] can be used. The data in Figure 1 were obtained using samples from FastColours and are to all intents and purposes identical to those shown in previous articles on this subject [3, 4].



**Figure 1** - Gel electrophoresis of mixtures of food dyes supplied by FastColours. Lanes numbered left to right [8].

## References

- [1] Curriculum for Excellence: Sciences - Experiences and outcomes – available at [http://www.ltscotland.org.uk/learningteachingand assessment/curriculumareas/sciences/eandos/index.asp](http://www.ltscotland.org.uk/learningteachingand%20assessment/curriculumareas/sciences/eandos/index.asp) (accessed September 12th 2011).
- [2] The Science 3-18 website is available at [www.science3-18.org](http://www.science3-18.org). Please note that to access all resources on the website you need to register and be provided with a log-on ID and password.
- [3] The Wonderful Wizardry of Finding a Gene, SSERC Bulletin (2007) **221**, 2-4.
- [4] The Wonderful Wizardry of Finding a Gene – Battery Free Method, SSERC Bulletin (2007) **222**, 11.
- [5] The National Centre for Biotechnology Education price list is available at [www.ncbe.reading.ac.uk/NCBE/MATERIALS/PDF/NCBEpricelist.pdf](http://www.ncbe.reading.ac.uk/NCBE/MATERIALS/PDF/NCBEpricelist.pdf) (accessed September 12th 2011).
- [6] A variety of food colours are available from the Dr. Oetker Online Shop at [http://www.oetkeronline.co.uk/categories/ Colours-%26-Flavours/](http://www.oetkeronline.co.uk/categories/Colours-%26-Flavours/) (accessed September 18th 2011).
- [7] Information about the ingredients in the Dr Oetker Natural Yellow and Natural Black Food Colours was obtained at [www.tesco.com/groceries/Product/Details/?id=256459508](http://www.tesco.com/groceries/Product/Details/?id=256459508) and [www.tesco.com/groceries/ Product/Details/?id=258153734](http://www.tesco.com/groceries/Product/Details/?id=258153734) respectively (accessed September 18th 2011).
- [8] FastColours (2011), Food dyes and Lakes – available at [http://www.fastcolours.co.uk /food-dyes—lakes-9-c.asp](http://www.fastcolours.co.uk/food-dyes—lakes-9-c.asp) (accessed 18th September 2011).

*Lane 1 – mixture of Quinoline yellow and Green S*

*Lane 2 – mixture of Brilliant blue, Quinoline yellow and Allura red*

*Lane 3 – mixture of Quinoline yellow, Green S and Carmiosine*

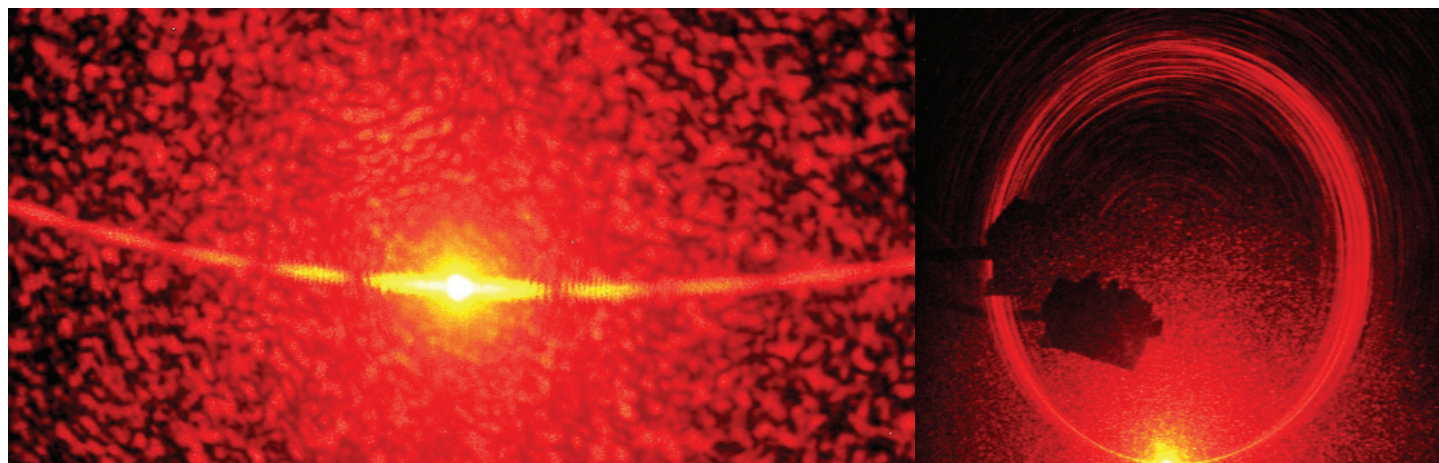
*Lane 4 – mixture of Brilliant blue, Quinoline yellow and Green S.*

## Hair Laser

We pass on details of a rather attractive diffraction experiment – because you're worth it.

A human hair [1] is the ideal diameter to show the diffraction of laser light. Figure 1 shows such a diffraction pattern, with characteristic maxima and minima, but note that it is curved.

The curvature comes about because the hair is not at right angles to the beam. The laser light strikes the hair obliquely, almost running along the strand. Indeed, it is possible to make a complete circle of laser light, as shown in Figure 2.

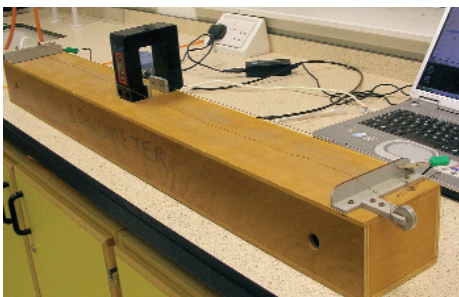


**[1]** – We know that some of you are thinking “Where did they get the hair?”.

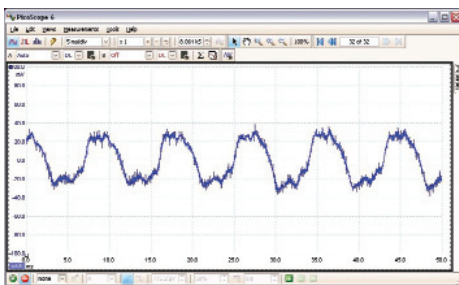
Here we look at three pieces of apparatus that offer features that you might not have come across before.



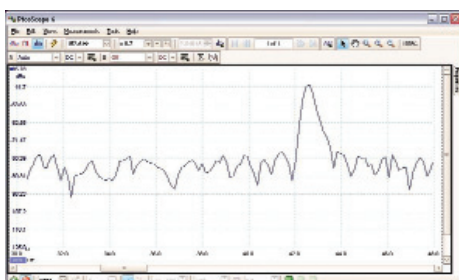
**Figure 1** - Picoscope USB oscilloscope



**Figure 2** - Apparatus set up by our plucky experimenter.



**Figure 3** - Trace from plucked sonometer wire.



**Figure 4** - Frequency spectrum plot (zoomed).

## Picoscope USB oscilloscope

First up is the Picoscope 2203 (Figure 1) from Picotech [1].

Connected to the USB port of a computer running the supplied software, this device becomes a two channel oscilloscope with signal generator output. To investigate it, we connected the Picoscope across a sonometer wire that was plucked in a magnetic field (Figure 2).

The trace is shown in Figure 3. Freezing a trace involves pressing the spacebar.

The software can be set to automatically select the most appropriate y-gain. Timebase settings are selected from a drop down menu. We found the frequency spectrum feature to be very useful for experiments such as the one above. An example of a frequency spectrum plot is shown in Figure 4. The zoom feature of the software has been used to examine the fundamental frequency of the plucked wire.

Our Picoscope sampled at 40 MHz if used in single channel mode, or 20 MHz if both channels were used. Accuracy is quoted as "8 bits". Thus, the selected voltage range is divided into 256 ( $2^8$ ). On the most sensitive range, which reads from -50 mV to +50 mV, a range of 100 mV, the smallest division is therefore  $100 \div 256$ , or around 0.4 mV. However, software enhancement can increase this by a further 4 bits. A full technical specification is available from the manufacturer [2].

The Picoscope is a genuine oscilloscope that does everything a CRO does, and it does it to the same level of accuracy as any device likely to be bought for a school. It has other useful features, such as the aforementioned frequency spectrum analysis tool and its output can be displayed on a large screen if the computer is hooked up to a projector. Our only reservation about the Picoscope is that it is a box connected to a computer and, unlike a CRO, its innards are unlikely to be comprehended by the average user.

## Lascells Digital Signal Generator

We paid extra to have our Picoscope calibrated, so that we could use it as a test instrument. This helped us to assess our next piece of apparatus, the Lascells Digital Signal Generator [3]. This is pictured in Figure 5a.

Note the digital display (Figure 5b) that gives the frequency and output voltage. We were particularly interested in the former, because the markings on conventional signal generators are notoriously inaccurate, especially if we Johnny has given the frequency dial a hearty twist, causing it to slip on its mounting spindle. We checked the accuracy of the display reading by using our Picoscope's frequency analyser. We sampled the sinusoidal signal from the Lascells unit at different frequencies throughout its range, taking several readings per frequency. In all cases, the reading on the display was within two standard deviations of the mean reading from the Picoscope. Given that the timebase of the Picoscope has a stated accuracy of 100 ppm (parts per million), it is clear that the Lascells Digital Signal Generator display is orders of magnitude more accurate than a signal generator with a rotary dial. The manufacturer quotes an accuracy of between 0.1% and 0.5%. The unit, as can be seen from the picture, can produce square,

sinusoidal and sawtooth signals. It has a high impedance CRO output and a lower impedance power output for a loudspeaker or vibration generator. Note that we intend to do a fuller test of this equipment, in the near future.

## Data Harvest EasySense Vision

A couple of years ago, we got quite excited at some recently introduced hand-held dataloggers [4]. Last year, along came the Pasco Spark, and impressed us with its relatively large touch screen [5]. Now, Data Harvest have brought out their own device, the EasySense Vision [6]. So, here is another 12-bit interface with a touch screen and 50 kHz maximum capture rate (Figure 6).

Are we still excited? Actually, yes. The common thread running through this article is "features you might not have come across before". In the case of the EasySense Vision, Figure 7 reveals something we have not seen on the other handhelds reviewed to date.

The Vision has a VGA port. It can connect directly to a monitor or LCD projector without having to hook up to a computer, though it is still capable of doing so. The facility for pupils to be able to show data they have gathered to the rest of the class simply by plugging in the logger to a projector is appealing.

We know that when we review equipment in the current financial climate many readers will tell us that they have no money. Is it cheeky to suggest that manufacturers of modern equipment like that reviewed above badge their apparatus with a year number such as Picoscope 2011? School computer systems seem reasonably up to date....

## References

- [1] [www.picotech.com](http://www.picotech.com). Model 2203 £159 at the time of review
- [2] <http://www.picotech.com/picoscope2200-specifications.htm>
- [3] [http://www.lascells.com/product\\_info.php?product=191](http://www.lascells.com/product_info.php?product=191)  
Also available from other suppliers, including Scientific and Chemical Supplies, who lent us the test model.  
[www.scichem.com](http://www.scichem.com), product code XWV680010. £218 (Timstar) at the time of review.
- [4] <http://www.sserc.org.uk/members/SafetyNet/bulls/226/Interfaces.htm>
- [5] [http://www.sserc.org.uk/members/SafetyNet/bulls/231/Pasco\\_Spark.htm](http://www.sserc.org.uk/members/SafetyNet/bulls/231/Pasco_Spark.htm)
- [6] [www.dataharvest.co.uk](http://www.dataharvest.co.uk), product code 2020. £279 at the time of review



Figure 5a - Lascells Digital Signal Generator.



Figure 5b - Digital display with frequency & output voltage.



Figure 6 - Data Harvest EasySense Vision.



Figure 7 - Spot the port.

The law on radioactivity is of a complexity that defies belief. One part of it, on exemptions to the Radioactive Substances Act 1993, has just been modernised. This is the part of the law controlling what sources you ('you' in this context meaning a school) are allowed to acquire and keep, and, at the end of the material's working life, how it can be got rid of.

As an aside, to make the point that we are here writing about just one part of the law on radioactivity, albeit an important part, the complete set of legislation that wraps red tape around what is done in schools is shown (Table 1). This means that you cannot just follow one part of the law to get by. All of it has to be considered.

Many of you experienced the inadequacies of the old exemption orders. They were exposed by the National Survey of 2006 and subsequent disposal. From the Survey it was found that almost half of the radioactive articles or materials were being kept without the legal right to do so.

When it came to trying to dispose of those unlawfully-held sources, there were often no easy means of disposal that were within the law. A special contractor, at great expense, was engaged by the government to remove this waste. These difficulties arose because the old exemption orders were not fit for purpose.

There is now one new exemption order replacing the eighteen old ones. The new one strikes a balance between, on the one hand, the recognition that radioactivity is harmful – and, in large quantities, dangerous – and, on the other hand, the fact

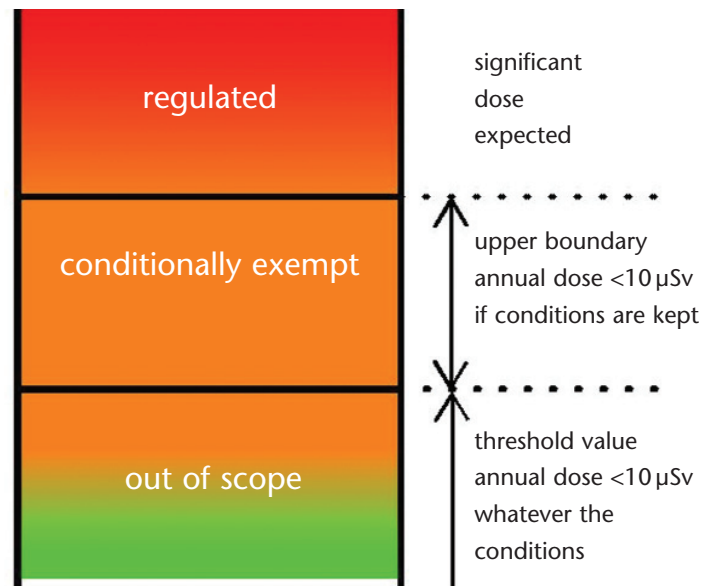


Figure 1 - Control status.

that everything, absolutely everything, whether natural or manmade, is radioactive.

The new law sets threshold values for every type of radionuclide, or concentration thereof. If the activity of a material is below the threshold, the material is 'out of scope' meaning that regulation is not necessary (Figure 1).

If the material is above the threshold, but still within certain bounds, the material is conditionally exempt from regulation, meaning that the controls are a light touch. Anyone wanting to buy an exempt source or dispose of it would not have to apply to the government regulator (SEPA) for a permit.

Legislation on radioactivity	Purpose
Radioactive Substances Act 1993 Exemption Order 2011 [1]	Controls the acquisition, keeping and disposal of radioactive materials
Ionising Radiations Regulations 1999	Sets health and safety regulations – relates to working practices
Justification Regulations 2004	To prevent use of radioactive materials unless there is good cause
Education (Amendment) (Scotland) Act 1984 Circular 1166 (1987)	Sets restrictions and conditions on work by children, students, teachers and schools Controls the acquisition of sources by schools
Transport of Dangerous Goods etc Regulations 2009	Controls shipment by road of radioactive materials

Table 1 - Legislation relevant to schools.

Radioactive material	Regulatory status on acquisition and disposal	Means of disposal
Sealed sources, < 200 kBq	Conditionally exempt	Dustbin
Sealed source, 370 kBq Cs-137	Conditionally exempt	Dustbin after decaying for 30 years
Ba-137m eluting source, < 40 kBq	Conditionally exempt	Article to dustbin Eluate to drain
Thoriated gas mantle	Out of scope	Dustbin
Geological specimens	Out of scope	Dustbin
Protactinium generator (seek advice)	Conditionally exempt	Dustbin (unopened), or chemical waste
Thoriated welding rod	Conditionally exempt	Dustbin
Potassium and compounds	Out of scope	As chemical waste
Orphan source, any article < 40 kBq	Not applicable	Dustbin

**Table 2** - Status of school sources under new exemption order.

However a school must still apply to the Scottish Government Education Directive for permission to purchase a radioactive source. That rule still holds under different legislation (Table 1). To work with materials outside these boundaries, a government permit would have to be applied for and obtained. The materials are then said to be 'regulated'.

The threshold values referred to above are based on the maximum dose of radiation a member of the public might get from keeping and working with out-of-scope materials. This is a dose of 10  $\mu$ Sv/year. It is generally accepted that the risk of harm from a whole-body dose of 10  $\mu$ Sv/year is insignificant.

To understand how this risk-based approach to regulation applies to exempt sources – the second tier of regulation – consider the example of a teacher-demonstration experiment with a sealed source emitting either beta or gamma radiation. The dose to the teacher, provided that standard precautions are taken, is unlikely to exceed 0.1  $\mu$ Sv. With this figure in mind,

only the most dogged teacher-experimenter, of febrile intent, could possibly amass a dose of 10  $\mu$ Sv in one year with one such source. In other words, the annual dose from work with an exempt source is very unlikely to reach the threshold value.

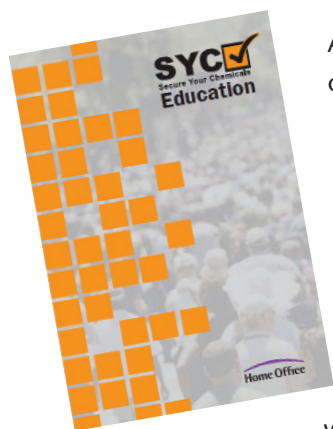
SSERC has put much effort into helping the government draft this new legislation. Here (Table 2) is how it applies to the types of materials now held in schools.

In conclusion, the replacement of the old exemption orders with the single new one is good news for schools. Do take care that although the sources listed in Table 2 are either marked as 'exempt' or 'out of scope' from regulation, these qualifications relate to the Radioactive Substances Act. All of the other regulations in Table 1 apply and should be followed. The law is complicated. That's why schools are obliged to consult with a radiation protection adviser (RPA). The above report is only a rough guide to the new law.

## Reference

[1] <http://www.defra.gov.uk/publications/2011/09/14/pb13624-ep-guidance-radioactive/>

Many of you will now have seen the aforementioned document. It is available for download from the front page of the new SSERC website [1]. Hopefully you should realise that there is no cause for alarm. It is worthwhile, however, running through a summary of the document and its implication for school science departments.



### Background

As part of a general tightening up of access to potentially dangerous chemicals, particularly in light of current security concerns, the Home Office approached SSERC and CLEAPSS with a document they had produced for industry with a view to our adapting it for educational use. After a certain amount of to and fro, we managed to come up with the document *Secure Your Chemicals*.

Some of the chemicals listed are of obvious concern in many ways, such as mercury, but a look through the list will suggest that the main worry is fire/explosion so most of the chemicals named are either flammable or oxidising and while many are fairly innocuous on their own, in combination, they can be hazardous.

### Actions

Good management practice would dictate that schools should already be doing almost everything that this document suggests but here is a summary :-

1. Chemicals should be kept securely and access limited to authorised personnel only and as small a number as is practicable.
2. A regular audit (stocktake) should be carried out of chemicals in store.
3. Chemicals should only be ordered by authorised personnel and should be recorded and stored safely immediately upon arrival.
4. There are certain chemicals (see list) which are of particular concern and technicians/teachers should keep an eye out to make sure these in particular are secure.
5. If any of the chemicals on the list are noted as having gone missing

- a) Double check that stock really is missing with all staff members.
  - b) Record as much detail as possible about missing stock or a suspicious incident. Include names, times, dates and list the name and quantities of the chemicals missing.
  - c) Contact your local police if you find any of the chemicals listed unaccounted for.
  - d) If you think that the loss may be related to terrorism contact the Anti-Terrorist Hotline on 0800 789321.
6. If teachers/technicians are approached by people trying to purchase any of the chemicals on the list, this information should also be passed on to police.

### Chemicals causing most concern

Some of these could legitimately appear in more than one category (e.g. nitric acid is an oxidising agent as well as an acid) but it makes sense that they do not appear more than once :-

#### Solvents

- propanone (acetone),  $\text{CH}_3\text{COCH}_3$
- alcohol (ethanol, methanol; solutions greater than 50%),  $\text{C}_2\text{H}_5\text{OH}$  or  $\text{CH}_3\text{OH}$
- nitrobenzene,  $\text{C}_6\text{H}_5\text{NO}_2$
- nitromethane,  $\text{CH}_3\text{NO}_2$
- ethane-1,2-diol (ethylene glycol),  $\text{HOCH}_2\text{CH}_2\text{OH}$
- propane-1,2,3-triol (glycerine/glycerol),  $\text{C}_3\text{H}_8\text{O}_3/\text{CH}_2\text{OHCH}(\text{OH})\text{CH}_2\text{OH}$
- butan-2-one (methyl ethyl ketone),  $\text{CH}_3\text{COCH}_2\text{CH}_3$



#### Acids

- concentrated (glacial) ethanoic acid (acetic acid),  $\text{CH}_3\text{COOH}$
- citric acid,  $\text{C}_6\text{H}_8\text{O}_7$
- concentrated hydrochloric acid,  $\text{HCl}$
- concentrated sulphuric(VI) acid,  $\text{H}_2\text{SO}_4$
- concentrated nitric(V) acid,  $\text{HNO}_3$



#### Oxidising Agents

- ammonium nitrate(V),  $\text{NH}_4\text{NO}_3$
- any chlorate(V/VII) (Perchlorate),  $\text{NaClO}_3$  /  $\text{KClO}_3$  or  $\text{NaClO}_4$  /  $\text{KClO}_4$  /  $\text{NH}_4\text{ClO}_4$
- any nitrate,  $\text{KNO}_3$  /  $\text{NaNO}_3$
- hydrogen peroxide,  $\text{H}_2\text{O}_2$
- lead nitrate(V),  $\text{Pb}(\text{NO}_3)_2$
- calcium chlorate(I) (calcium hypochlorite),  $\text{Ca}(\text{OCl})_2$
- solid potassium manganate(VII) (permanganate),  $\text{KMnO}_4$





## Others

- hexamine/hexamethylene tetramine,  $C_6H_{12}N_4$
- mercury, Hg
- 2,2-bis(hydroxymethyl)1, 3-propanediol (pentaerythritol),  $C(CH_2OH)_4$
- powdered metals (aluminium (Al), magnesium (Mg), magnalium (Al/Mg), zinc (Zn))
- sodium azide,  $NaN_3$
- sulphur, S
- urea,  $CO(NH_2)_2$

This list should not be considered as exhaustive. If you have other chemicals you think are similarly hazardous (perhaps acquired for an AH project) and they go missing, you should still follow the procedures above. If you have any doubt as to the threat posed by a chemical, check out the Hazardous Chemicals section [2] of the SSERC website and if that does not give you the information you need, contact us here at SSERC.

## References

- [1] - [http://www.science3-18.org/sserc/images/legacy/Hazardous\\_Chemicals/SYC\\_Education\\_Final.pdf](http://www.science3-18.org/sserc/images/legacy/Hazardous_Chemicals/SYC_Education_Final.pdf)  
 [2] - [http://www.science3-18.org/sserc/index.php?option=com\\_content&view=article&id=1083&Itemid=11](http://www.science3-18.org/sserc/index.php?option=com_content&view=article&id=1083&Itemid=11)



## Safety in numbers

The Reporting of Injuries, Diseases and Dangerous Occurrences Regulations (RIDDOR) legislation [1] places a duty on employers to report deaths, major injuries, three day injuries to employees (injuries that result in three or more days off work) and injuries that result in members of the public being taken to hospital.

In a state school setting, the employer is the local authority, teachers and support staff are employees and pupils are members of the public. Reports are made to the Health and Safety Executive.

The HSE has sent us the Scottish education sector RIDDOR data for session 2009 / 2010. In that period, there was one fatality, when an electrician was killed by a high fall. Around 350 employees were injured, with numbers in primary and secondary schools roughly equal. Approximately a quarter of those hurt were teachers or technicians. The number of reports where the subject was a member of the public was 632, the vast majority being pupils, with almost twice as many secondary as primary children injured. On average, each Scottish secondary school had one RIDDOR incident involving a pupil in this year-long period.

The figures break down the accidents by type. We were particularly interested in those that came under the heading of "contact with harmful substance", though we have no way of knowing if they happened in science or technology classes. Only 2% of pupil accidents and 3% of employee accidents fell into this category. The most common causes of injuries were slips and trips, accounting for 40% of the total.

Remember that we are not talking about trivial "skint ma knee" injuries here. Overall, the HSE data reinforces the view that schools are largely safe places in which to work and learn. This is not complacency. Indeed, schools are safe because employers and employees are, by and large, not complacent about safety, particularly when the risk is potentially high if not carefully controlled. As ever, there are areas where we can improve, particularly with respect to slips and trips. The HSE's website [2] has very useful information, including guidance, advice and case studies.

## References

- [1] <http://www.hse.gov.uk/riddor/riddor.htm>  
 [2] <http://www.hse.gov.uk/slips/index.htm>

**Gas explosions caused by static electricity**

There are two types of explosion which can result from the ignition of a gas-air mixture by a spark discharge. These are known as 'confined' and 'unconfined' gas-air explosions. With the former type there is a massive rise in pressure with temperature, which can result in the chamber blowing apart explosively (Figure 1). With the latter, there is a large sheet of flame (Figure 2) caused by the expansion of the gaseous mixture with temperature, and a consequential risk of fire. If gas leaks into a building, one way or another, there is a risk of harm to the property, and life or limb.

**Equipment**

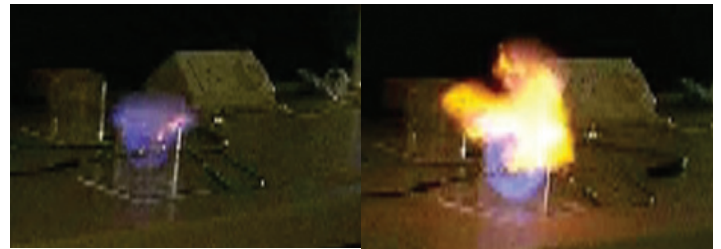
- Explosion chamber with electrodes
- Van de Graaff generator (VdG)
- Discharge sphere
- Tubing from gas tap

**Description**

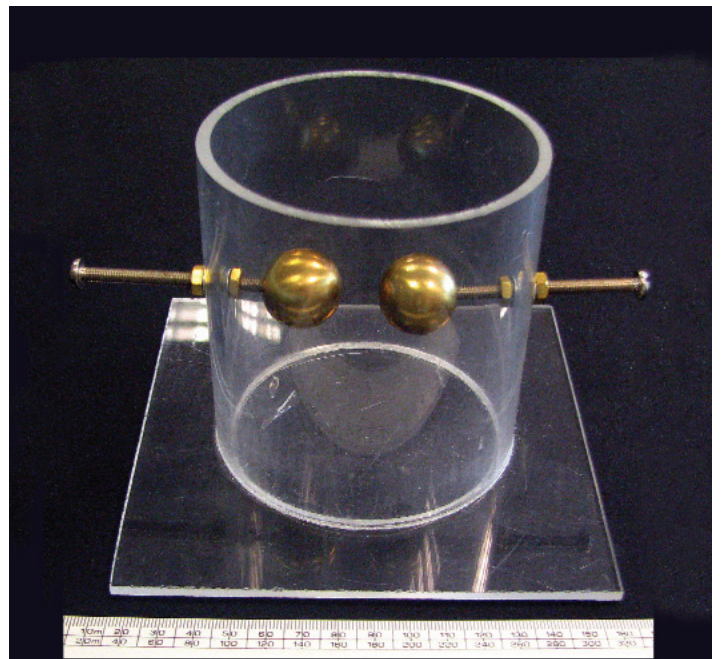
A mixture of methane and air is explosive when the concentration of methane lies in the range from 5% to 15%. The explosion is set off by an electrostatic spark. When the mixture ignites, the rapid increase in temperature brings about a huge increase in gas pressure. If the burning vapour were to be confined the resulting rise in pressure could destroy the chamber with a loud explosion. In this demonstration there is no risk of harm because of the flimsy nature of the chamber's lid. It is nothing more than a paper cap held down (for making a confined-vapour explosion) with an elastic band, or just the weight of paper (for making an unconfined-vapour explosion).

**Explosion chamber**

The explosion chamber (Fig. 3) was to our design and made for us by Wilson Fraser of Schools' Laboratory Equipment. The chamber is made of transparent Perspex comprising a short tube, 80 mm long, 84 mm outer diameter and 78 mm internal diameter, cemented to a plane base. The lid, being the one flimsy part, is a paper cap, which can either rest unsecured (Figure 4), or be clamped down by an elastic band (Figure 5). The two electrodes each consist of a 20 mm diameter brass sphere mounted on screwed rod, fastened with a pair of nuts at the chamber wall. The gap between the spheres is adjusted such that a large spark can jump from one to the other when the VdG is operating. In our setup the length of the spark gap is 15 mm.



*Figures 1 & 2 - Confined (left & unconfined (right). Note that as these explosions are transient events the still images above may not fully portray what happens in these explosions.*



*Figure 3 - Explosion chamber.*

## Method

The external contact on one of the electrodes on the explosion chamber is connected to the earth socket on the VdG. The external contact on the other electrode is connected to the VdG dome. Gas from the lab supply is allowed to flow into the chamber for about one second. The hose is removed and the paper cap is placed on the chamber. The VdG is switched on and set to run slowly, causing large sparks between the electrodes in the chamber. When the air-gas concentration becomes critical, the mixture explodes. For the confined-vapour explosion, the cap blows off and it and the elastic band can be thrown up to 2 m distant. There is a low pop and a small flame (Figure 1). For the unconfined-vapour explosion, the cap lifts off and is overturned, and a large flame emerges from the chamber with a whoosh (Figure 2).

With the above method, it is assumed that the gas-air mixture is too rich in methane for an explosion to take place at the onset of sparking. It is only after some of the methane leaks out that the mixture goes critical. A suggestion for starting off with the mixture critical would be to fill a gas syringe with 40 cm<sup>3</sup> of methane and inject this into the chamber, then immediately seal with a cap. Knowing that the volume of the chamber is 380 cm<sup>3</sup> this should give a concentration of 10% methane and produce an energetic explosion.

## Outcomes

The explosions dramatically show different aspects of the gas laws, either rapid expansion, or rise in pressure with temperature. They show the danger of static electricity and its propensity to start fires or explosions. They make the point that the main risk of injury from an unconfined-vapour explosion is burn or fire, whereas from a confined-vapour explosion it is blast.

## Curricular links

Static electricity features several times in the physics courses. The hazards are often mentioned but rarely demonstrated. The activity could also be used in chemistry when fuels are covered, for example in Unit 5, Standard Grade.

## Risk assessment

Provided that the demonstrator and onlookers are no closer than one metre from the chamber, there is no risk of harm from following the above method. Apart from wearing eye protection, no other control measures need to be taken. However if the method were to be changed, there could be a risk of a dangerous explosion. Please look at the Risk Assessment on the SSERC website (<http://tinyurl.com/3uj5gas>)

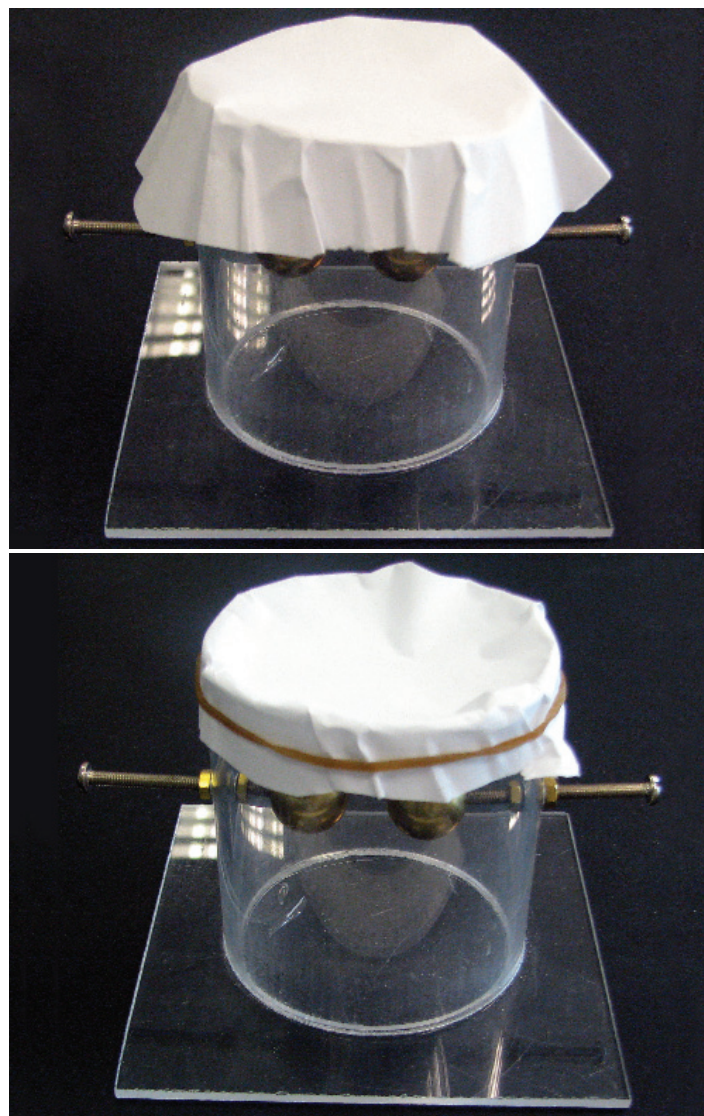


Figure 4 & 5 - Explosion chamber with loose-fitting cap (top) and tight-fitting cap (bottom).



The Code of Practice Safety in Microbiology [1] was produced and developed by SSERC for use in Scottish schools and FE colleges. SSERC is a Local Authority (LA) shared service so all LA schools can access the SSERC advisory service. Many independent schools and some FE colleges are also members of SSERC. Most LAs have adopted Safety in Microbiology as part of their guidance on Health and Safety. Where this is the case schools should work to the Code of Practice. If schools do not use Safety in Microbiology as a Code of Practice, or wish to depart from its recommendations in some way, they must carry out the appropriate risk assessments.

The Safety in Microbiology Code of Practice is the result of risk assessment and describes control measures for microbiology laboratory work in schools and colleges. As with all generic health and safety guidance, this Code of Practice must be reviewed to take account of local circumstances e.g. suitability of working area.

In Safety in Microbiology, work in microbiology is described at three levels, largely related to the educational stage of pupils and students. A summary of training requirements to lead practical work in microbiology is summarised below:

- For level 1 work no specialist training is required beyond following the guidance in Safety in Microbiology.
- For class laboratory work at level 2 a teacher does not require to be trained to level 3. However, teachers should be experienced in school laboratory work, must follow the guidance in Safety in Microbiology and be trained to deal with microbiological spillages.
- For preparation and disposal of materials for level 2 work, a technician or teacher trained to level 3 is required to carry out the following tasks:
  - a) order, receipt, labelling and storage of cultures
  - b) preparation of sterile media and sterile equipment
  - c) sub-culturing
  - d) sampling from bioreactors
  - e) sterilisation and disposal of cultures
  - f) sterilisation of used equipment
  - g) management of incidents of spillage
  - h) staining of incubated plates (e.g. starch agar)

**References**

[1] SSERC (2002) Safety in Microbiology: A Code of Practice for Scottish Schools and Colleges.

This document can be downloaded from the SSERC website ([www.sserc.org.uk](http://www.sserc.org.uk)) [Accessed 18th September 2011].

Please note that to access resources on the SSERC website you will need to register and be provided with a log-on ID and password. See also the new SSERC website at:-

[http://www.science3-18.org/sserc/index.php?option=com\\_content&view=category&id=269&Itemid=336](http://www.science3-18.org/sserc/index.php?option=com_content&view=category&id=269&Itemid=336)



Local Authority Training Partnership(s), some FE colleges and SSERC can provide training to level 3.

**Determination of competence to carry out level 3 tasks.**

A teacher or technician is considered competent to carry out level 3 tasks if they have undertaken and achieved the competence standards of the SQA accredited SSERC course, Safety in Microbiology for Schools (level 3).

Local Authorities may consider an individual competent if they have undertaken a degree, course or work-based training that allows them to meet the same competence standard within the last five years.