



SSERC Bulletin

No. 236 ■ Summer 2011

Ideas and Inspiration supporting Science & Technology for all Local Authorities



Ultraviolet and Infrared - hidden radiations
Rocks to Riches
Antioxidants: Recipe Remedies
Fun with Fluorescence!
RF radiation risk – in whom should you believe?
Used-battery fire
Secure storage of chemicals
Technology Roundup





Ultraviolet and infrared...

A guide to practical work on the two hidden parts of optical radiation – ultraviolet and infrared – has been placed on the SSERC website [1]. This article gives an overview of its contents. The full guide contains detailed descriptions of all experimental set-ups and, where appropriate, lists product codes and shows circuit diagrams.

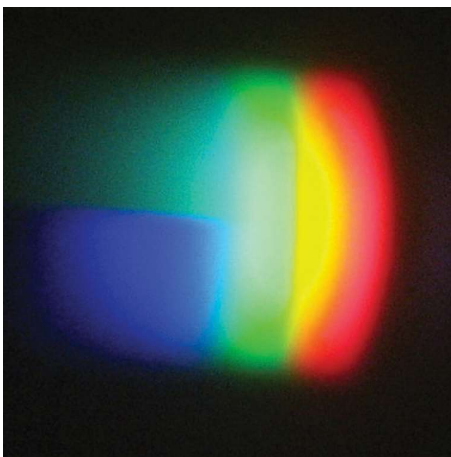


Figure 1 – Spectrum focused on split screen.

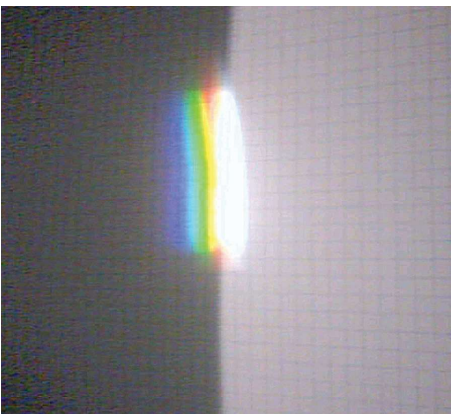


Figure 2 – Webcam – filter removed.



Figure 3 – Webcam with longpass filter.

Showing the three parts of optical radiation

A hot filament tungsten-halide lamp is a good source of all three types of optical radiation (ultraviolet, visible and infrared). To show all three components, a spectrum should be produced in the standard way (vertical slit, converging lens and crown glass prism). If the spectrum is focused on a split screen whose upper half is fluorescing, fluorescence is seen far beyond the limit of visible violet (Figure 1). Our photograph misleads. Whereas the bottom half is a fair representation of what the eye sees, although it renders violet blue, the top half, because of contrast, fails to show the weak fluorescence which extends far to the left of visible violet.

With the same spectrum, if a silicon photodiode is moved across the spectrum, the signal it picks up increases as the device is scanned from violet across to red, and continues to rise when moved into the dark region to the right of red. This shows the presence of an invisible radiation (which we call infrared) beyond red and it suggests that the lamp's output is more intense in infrared than in visible. However we have to be careful in how we interpret this. One complication is that a photodiode's spectral response may not be flat (it probably peaks in the near-infrared). Another complication is that the colours in a spectrum are packed together more tightly at the red end when the spectrum is produced with a prism.

A webcam is just a 2-d array of silicon photodiodes with some optics. It is usually fitted with a shortpass filter to transmit visible radiation but block infrared. When the filter is removed, the image of the spectrum has a bright white section to the right of, and partly overlapping, the red section (Figure 2). The bright white part is the infrared component.

When a longpass filter (one which blocks visible but transmits infrared radiation) is held in front of the camera, only the infrared component of the lamp's output is seen on the modified webcam's image (Figure 3).

UV optics

A convenient source of ultraviolet radiation in optics experiments is a 370 nm LED. This is a narrow-band radiation emitter (from 350 nm to 390 nm), most of whose output is invisible (the pale violet glow is perhaps less than 1% of the total output). (You can get UV LEDs whose output is invisible, but they are more expensive than the one we recommend.) It is a simple soldering job to wire it up (Figure 4). Ensure that it can be set up at the same height as the lenses and mirrors you will be working with.

UV radiation of wavelength 370 nm causes photocopier paper to fluoresce strongly. Although the radiation is invisible it is easy to track by searching with a small slip of this paper type.

A converging lens in front of the UV LED (Figure 5) collimates the radiation, directing it on a concave mirror one metre distant. The reflected radiation is

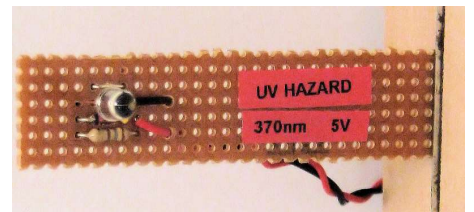


Figure 4 – Ultraviolet LED.



Figure 5 – Optics with ultraviolet LED - reflection.

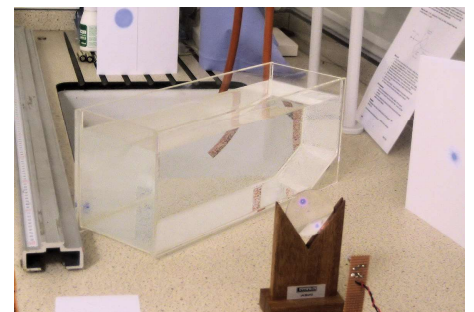


Figure 6 – Optics with ultraviolet LED - refraction.

...the hidden radiations

brought to a focus on a paper screen, seen as an intense circular patch above the wooden block that supports the screen. The left-hand edge of the screen clips the collimated beam before the main part of it reaches the mirror.

A collimated beam of UV radiation (Figure 6) is directed to fall, centrally, on the vertical line on the screen. If a rectangular tank of water is placed in the radiation and turned about a vertical axis, the beam is displaced because it refracts when it enters and exits the tank. Some of the radiation is reflected rightwards off the front surface of the tank.

The set of interference fringes (Figure 7) were formed by focusing radiation from a vertical array of four LEDs (in ascending order: infrared, red, green and ultraviolet) on a white paper screen through a grating (80 lines/mm). The UV fringes show as a result of fluorescence, being cyan-coloured. The IR fringes are invisible. They can be found by searching for them with a photodiode.

Near-IR optics

In order of difficulty, visible is the easiest optical radiation to work with, UV is next because you can search for it with a slip of fluorescing paper, and IR is the hardest because to find it you need an electronic or heat-detecting sensor. In this section we will restrict our discussion to near-infrared radiation with a wavelength between 700 nm and 1.1 μm). The reason for this is that sources and detectors are cheap and simple. An infrared LED is a convenient source. An infrared phototransistor or photodiode is a convenient detector.

Apparatus for showing the inverse-square law with infrared radiation is

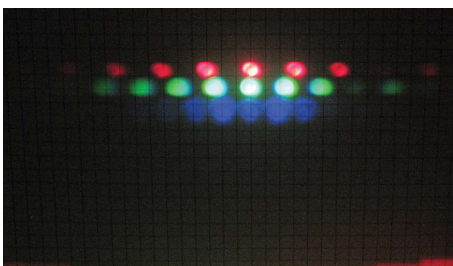


Figure 7 – Interference fringes from vertical array of 4 LEDs.

shown in Figure 8. The source is an IR LED mounted on the hidden side of the circuit board at the right-hand side of the photograph. The 35 mm slide mount holds a diffuser and acts as the point source in the experiment. The detector, a photodiode, is moved along the metre scale. Both it and the emitter are raised off the bench to avoid the radiation at the detector being augmented with reflections.

Heat radiation

Historically it was known at the time of Newton that heat rays could be focused like light. An experimental challenge is how to show that heat radiation from a non-luminous source – either a 2 inch diameter steel ball heated until just short of red hot, or a flask of near-boiling water – can be reflected and focused by polished metal surfaces, but not transmitted by glass. One simple heat-sensing detector is a black-bulb thermometer. Another is a miniature, blackened thermistor. Yet another is the thermopile (Figure 9). The output of this one is calibrated in watts per square metre.

The radiant efficiency of a lamp can be found by an energy audit. The hot-filament lamp is immersed in water (Figure 10). The heat dissipated by the lamp is found from the rise in temperature of the water. This is compared with the electrical energy transmitted to the lamp.

The seasons are explained by a model of the Earth orbiting around the Sun, which it does once a year. The Sun is represented by a radiant heater of the type that radiates in all directions equally (isotropically). A globe made from heat-sensitive paper is moved in a horizontal plane from position to position taking care to keep the inclination and direction of the polar axis constant (Figure 11).

Details of thirty experiments, the common theme being that they all are with invisible optical radiation, have been placed on the SSERC website. More may be added. Please contact us for further help, to suggest improvements, or to submit new ones.

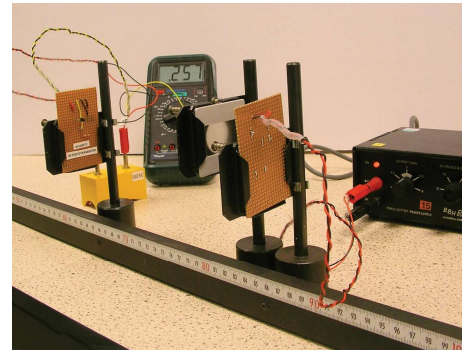


Figure 8 – Showing the inverse-square law with infrared radiation.



Figure 9 – Thermopile.

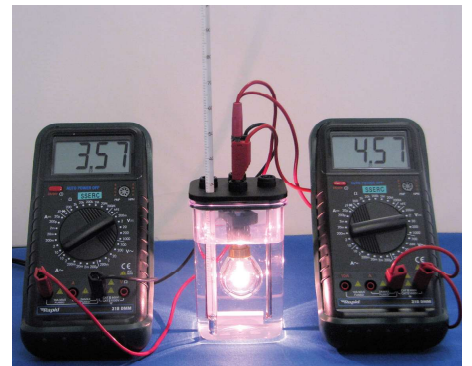


Figure 10 – An energy audit to determine the radiant efficiency of a lamp.



Figure 11 – Sun and the seasons model.

Reference

- [1] http://www.science3-18.org/sserc/index.php?option=com_content&view=category&id=126&Itemid=120



Rocks to Riches

Introduction

We outline here a practical activity that uses simple colorimetric analysis [1], to determine the percentage of copper in a simulated mineral-rich ore. This activity considers how market demands determine the economic viability of extracting the copper and how by simple electrolysis [2] the copper is refined in order for it to be used in everyday products.

These practical activities can be linked to the following science experiences and outcomes from the CfE – The Sciences:

SCN 3-17b - I can participate in practical activities to extract useful substances from natural resources.

SCN 3-19a - Through experimentation, I can identify indicators of chemical reactions having occurred. I can describe ways of controlling the rate of reaction and can relate my findings to the world around me.

SCN 3-19b - I have helped to design and carry out practical activities to develop my understanding of chemical reactions involving the Earth's materials. I can explain how we apply knowledge of these reactions in practical ways.

Preparation of ores

For the simulated ore samples **A**, **B** and **C**, weigh out the following for each, mix in a mortar and pestle (Figure 1) and place in an appropriately labelled jar marked **Ore A**, **B** and **C**:



Figure 1 - Prepared ore containing activated charcoal and copper carbonate.

Ore A - 1 g of copper carbonate (Harmful) and 9 g of activated charcoal (Highly Flammable).

Ore B - 3 g of copper carbonate and 7 g of activated charcoal

Ore C - 9 g of copper carbonate and 1 g of activated charcoal.

Solvent Extraction (SX)

This is divided into two practical activities. The first activity prepares the standardised copper sulphate solutions for the colorimetry and the second extracts the mineral from the ore producing a solution to be compared against the standardised solutions.

Standardised solutions

Place 30 cm³ of 1M copper sulphate solution (Harmful and Dangerous to the Environment) into a 100 cm³ beaker and 40 cm³ of distilled water into another 100 cm³ beaker. Use a 10 cm³ syringe to add 2 cm³ of copper sulphate solution and 8 cm³ of distilled water to a test tube and place in a test-tube rack. Now make

up the rest of the comparison solutions given in Table 1. Arrange the test tubes in the rack in the same order. This can be seen in Figure 2.

Extracting the mineral from the ore

Place all of ore A (copper carbonate is Harmful and powdered activated charcoal is Highly Flammable) into a 250 cm³ glass beaker. Pour approximately 100 cm³ of 1M sulphuric acid (Irritant) into another 250 cm³ beaker. Add 80 cm³ of acid to the ore, 10 cm³ at a time, using a 10 cm³ syringe. Carefully stir the mixture each time until there are no more bubbles being formed. Use a filter funnel and paper to filter off any excess solid into a 100 cm³ conical flask and make up to 100 cm³ with distilled water. This can be seen in Figure 3. This must be kept if the electro-winning is to be done at a later stage.

Finding the percentage of copper in the ore

Use a 10 cm³ syringe, place 10 cm³ of the filtered solution into a test tube. Now

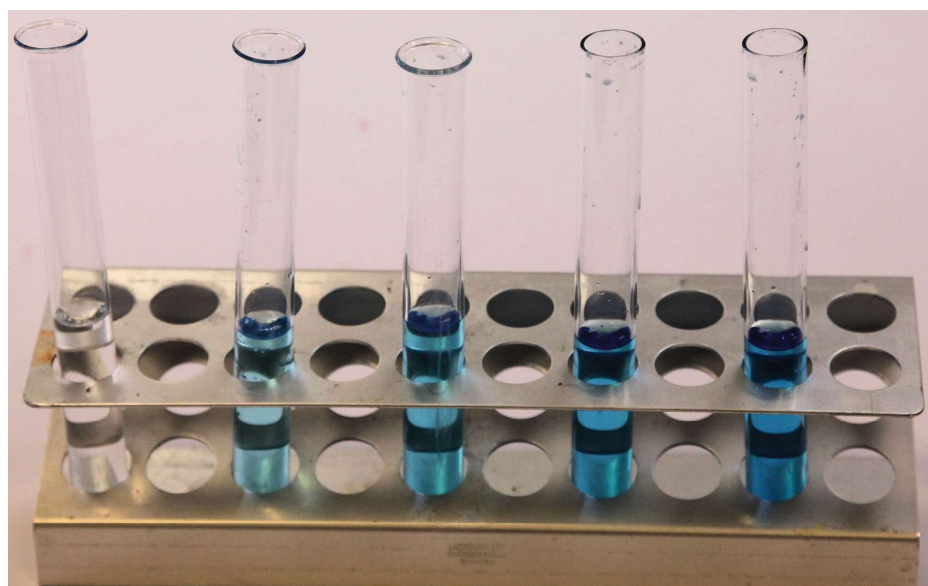


Figure 2 - Standardised solutions of copper sulphate solution.

Test Tube	1	2	3	4	5
Volume of Solution 1 (cm ³)	0	2	4	6	8
Volume of Water (cm ³)	10	8	6	4	2

Table 1 - Volume of copper sulphate solution to water for standardised solutions.



Figure 3 - Filtering and made up to 100cm³ in conical flask.

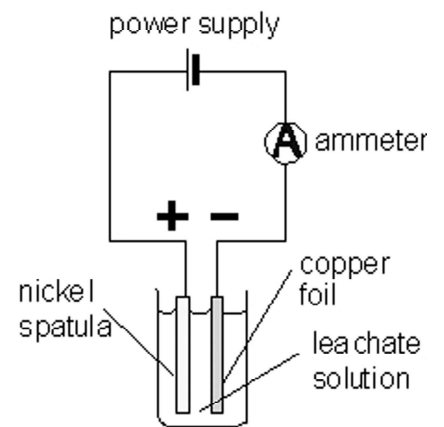
match the intensity or depth of colour of filtered solution against one of the standardised solutions. This is best done by looking through the test tube against a white background which is illustrated in Figure 4.

Note that the numeric values of copper in the ore have been given on a sliding scale to reflect that copper can be economically extracted from ores which contain 0.1 to 0.4% copper.

The instructions for the mineral extraction and determination of percentage of copper in the ore can be repeated for the other ore samples B and C.

Electro-Winning (EW) Extracting the copper from the leachate

Set up a circuit containing a power pack, a nickel spatula (electrode), a glass beaker and an ammeter as shown in Figures 5a & b. Use a piece of emery paper clean both sides of the copper strip and weigh it on a top pan balance.



Figures 5a & 5b - Electro-winning circuit.

This needs to be accurate to two decimal places. Now place the copper strip into the 100 cm³ beaker and make sure it is connected to the negative terminal (black connector). This can be seen in Figure 6.

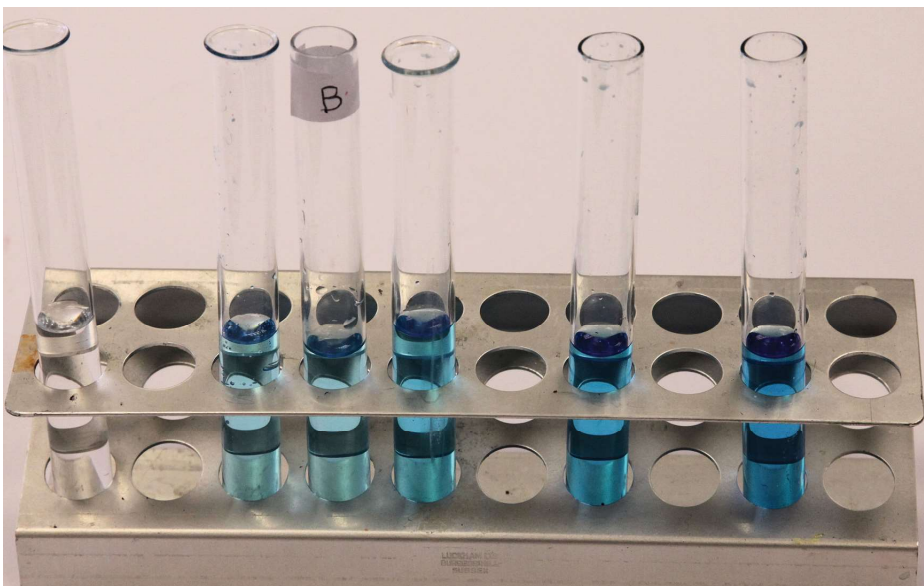


Figure 4 - Eye colorimetry.

Test Tube	1	2	3	4	5
Percentage of metal in ore (%)	0	0.13	0.26	0.39	0.51

Table 2 - The relationship between the standardised solutions and the percentage of copper present in the ore.

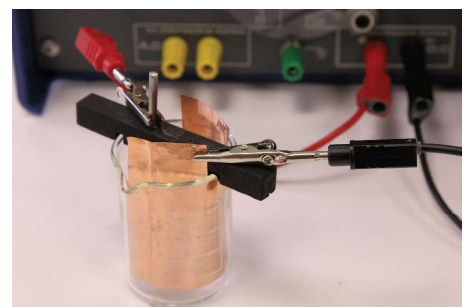


Figure 6 - Copper strip connect to black connector on power supply..



Rocks to Riches



Figure 7 - Tongs and hairdryer.

Carefully pour the leachate (Harmful and Dangerous for the Environment) with the highest percentage of copper into the beaker. You can also add 5 cm³ of 1M sulphuric acid (Irritant) as this will help to reduce the evolution of oxygen bubbles. Turn on the power supply (use only a low tension (LT) supply and not to exceed 16 volts d.c.), start the timer and adjust the output

voltage until the ammeter reads 1 Amp. Note you need to keep checking the ammeter and adjusting the output voltage to keep the current at 1 Amp. After 10 minutes, turn off the power supply. Hold the copper strip with a pair of tongs and using a hair dryer, carefully dry it. This can be seen in Figure 7. Once all the liquid has evaporated weigh the strip on the top pan balance.

References

- [1] www.practicalchemistry.org/experiments/colorimetric-determination-of-a-copper-ore,302,EX.html
 [2] www.practicalphysics.org/go/Experiment_676.html

Antioxidants: Recipe Remedies

Introduction

Since the article in Bulletin 232 [1], there has been an increase in the number of enquires for Advanced Higher projects concerning antioxidants. Here are some possible solutions to some common problems.

Recipes

It is good practice for a competent member of staff to prepare these solutions (wearing appropriate protective equipment) and carry out the risk assessment. The recipes for solutions A, B and C are as follows:

Solution A (potassium iodate and sulphuric acid)

Dissolve 10.75 g of potassium iodate (Oxidizing and Harmful) into a beaker containing 100 cm³ of distilled water. Place on a magnetic stirrer/hotplate. Slowly add 1.08 cm³ concentrated sulphuric acid (Corrosive) whilst stirring. Warm if necessary to dissolve the potassium iodate (KIO₃, not the periodate, KIO₄). Transfer solution to 250 cm³ measuring cylinder. Rinse beaker and add rinses to measuring cylinder. Make up to 250 cm³ with distilled water.

Reference

- [1] SSERC Bulletin 232, *Antioxidants: Tastes good, good for you?*, Summer 2010, p4
<http://www.science3-18.org/sserc/images/Bulletins/232/Antioxidants.pdf>

1.08 cm³ of sulphuric acid is a very precise amount but using a 1 cm³ syringe will enable you to get close enough. Alternatively, you can measure it out by mass – 1.08 cm³ = 1.99 g of concentrated sulphuric acid.

As the solubility of the iodate is approximately 12 g in 250 cm³ at 0°C if the solution is stored at low temperatures it can start to crystallise out. Simply apply gentle heat and stir until fully dissolved.

Solution B (malonic acid and manganese sulphate)

Add 0.08 g of starch to a small quantity of the distilled water to make a slurry. Boil approximately 75 cm³ distilled water and add the starch slurry, stirring until completely dissolved. Measure out 4.0 g of malonic acid (Harmful) and 0.85 g of manganese sulphate (Harmful). Add the solids to 100 cm³ of distilled water, stirring until dissolved. Add the starch solution. Transfer the solution to 250 cm³ measuring cylinder. Rinse the beaker and add rinses to measuring cylinder. Make up to 250 cm³ with distilled water.

Solution C (hydrogen peroxide)

Measure out approximately 100 cm³ distilled water into 400 cm³ beaker. Measure 75 cm³ of 100 vol hydrogen peroxide (Corrosive & powerful Oxidizing agent) into a 100 cm³ measuring cylinder.

Stirring continuously, add the hydrogen peroxide to the beaker. Rinse measuring cylinder and add rinses to the beaker containing the hydrogen peroxide. Transfer to a 250 cm³ measuring cylinder. Rinse the beaker and add rinses to measuring cylinder. Make up to 250 cm³ with distilled water.

Reference sample timings

What is of importance is the timing for the completion of the colour cycle. In further tests in the lab these have been on average as low 10 seconds.

Delay in colour cycle

As some foods contain relatively higher concentrations of antioxidants it can appear, after the addition of the sample, that the colour cycle has stopped. This may not be the case. Increasing the dilution factor for the sample may allow the completion of the colour cycle.

Fun with Fluorescence!



Fun with Fluorescence!

We are all probably familiar with materials which fluoresce. In this article we discuss some examples of fluorescence and how these can be explored in a classroom context. It is useful to consider what we mean by the term fluorescence and a useful starting definition is 'The emission of light by a substance that has absorbed light or other electromagnetic radiation of a different wavelength' [1]. With very few exceptions, the fluorescence emitted by a substance is at a longer wavelength than the light which has been absorbed (shown schematically in Figure 1).

In general, the colour of the incident light does not affect the colour of the emitted light provided the light is actually absorbed by the substance. So in the system shown in Figure 1 the blue light could be replaced with ultraviolet light and if this were absorbed it would still give rise to green fluorescence. An example of this phenomenon is shown in Figure 2 where we have placed a solution of fluorescein under UV, blue and red light. The fluorescence from the fluorescein solution is only observed with incident UV and blue light. Since both UV and blue light have greater energy than the colour of the emitted light [green/yellow]), fluorescence is produced. On the other hand red light, being of lower energy than the wavelengths of light emitted by the fluorescein, is not absorbed and so fails to produce fluorescence although some scattering of the red light can be observed.

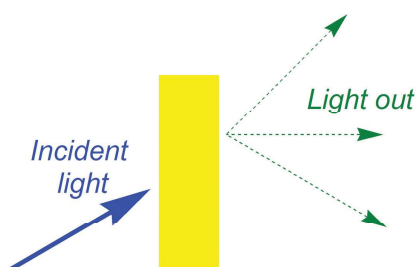


Figure 1 - Schematic representation of fluorescence. Incident, blue light is absorbed by a substance/object (shown in yellow) and fluorescence is shown as emitted green light.

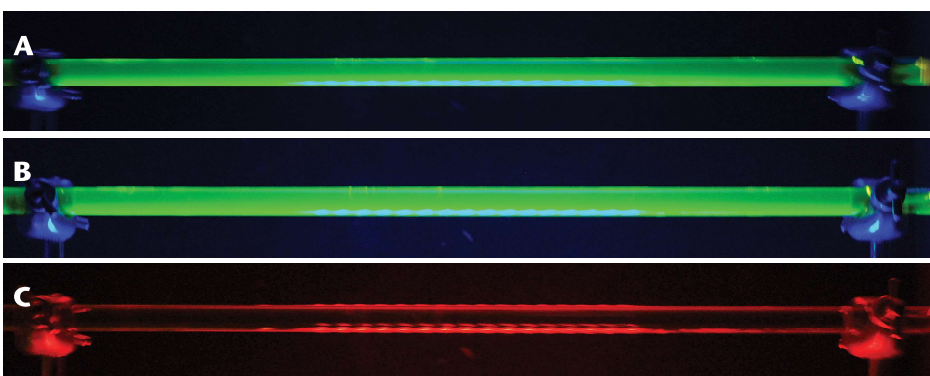


Figure 2 - Aqueous solution of fluorescein contained in a glass tube. (A) light source UV (365 nm); (B) light source blue (450 nm) (C) light source red (620 nm).

Fluorescence in the green-yellow part of the spectrum is often utilised in high-visibility materials. Fluorescence in this part of the visible spectrum is used because these colours are those most readily seen by eye although other colours (oranges and pinks) are also used in specialised cases (there is some interesting background information on high visibility clothing, and why certain colours are used, on the *Brightkidz* website [2]).



Figure 3 - High visibility jacket – image taken from [2].

The observation [3] that bananas display different fluorescent properties according to their ripeness (see Figure 4) was first noted in the literature as recently as 2008 and the phenomenon has been more widely explored by MacCormac *et al.* [4] who showed that a number of foodstuffs fluoresce when illuminated under UV light. The suggestion [5] of using welding equipment to observe fluorescence from bananas does, however, seem somewhat extreme. The blue fluorescence in bananas is thought [3] to arise from abundant “fluorescent” catabolites which are intermediates of chlorophyll breakdown. As the banana ripens further these intermediate catabolites are broken down into non-fluorescent products.

Encouraged by the relative ease with which fluorescence from foodstuffs can be seen, we decided to look at a range of samples in our local supermarket to see what might be available. So, for example in Figure 5 we show samples of split yellow peas (Tesco Whole Foods), soup

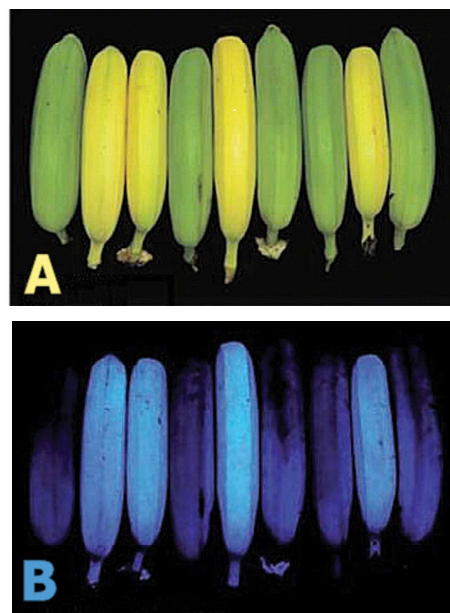


Figure 4 - Yellow bananas are blue luminescent. Yellow (ripe) and green (unripe) bananas under white light (A) and under UV light at a wavelength of 366 nm (B). Images taken from [3].



Fun with Fluorescence!

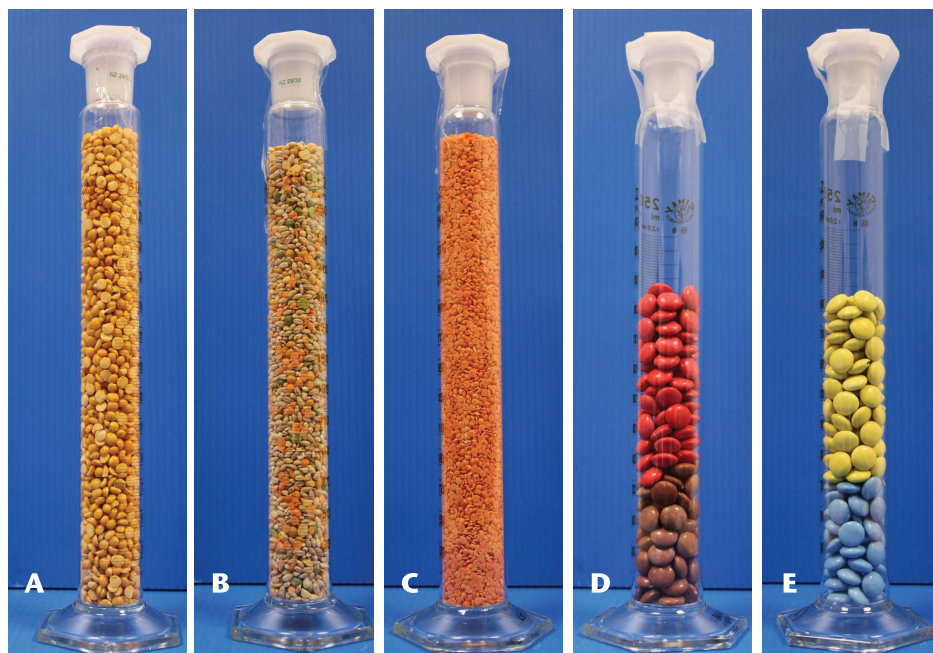


Figure 5 - Samples of (A) split yellow peas (Tesco 'Whole Foods'), (B) soup and broth mix (Tesco 'Whole Foods'), (C) red split lentils (Great Scot), (D) red and brown Smarties®, (E) yellow and blue Smarties®. All samples photographed under 'normal' laboratory lighting conditions.



Figure 6 - The effect of UV light (365 nm) on (from left) of split yellow peas, soup and broth mix, red split lentils, red and brown Smarties®, yellow and blue Smarties®.

and broth mix (Tesco *Whole Foods*), and red split lentils (*Great Scot*). In each case we show samples illuminated under laboratory conditions. Under UV light (Figure 6) it can be seen that red lentils emit bright orange/red fluorescence under these conditions. Some, but not all, of the fluorescence in the soup and broth mix arises from the red split lentils present (the composition on the packet is given as pearl barley 55%, yellow split peas 18%, green split peas 9%, marrowfat peas 9%, and red split lentils 9%). It seems unlikely in these cases that food additives are the cause of the observed fluorescence. Chlorophyll in red split lentils is reported [4] to be the molecule which gives rise to the red fluorescence.

Of course visiting your supermarket opens up all sorts of possibilities for exciting field trips and investigations in the confectionary aisle(s) (see images 5D and 5E). It should be pointed out that the rationale behind selecting a given product was based on personal choice rather than an attempt to make a comprehensive survey (sweets that turn out to be non-fluorescent are of course potentially available for consumption!). So, for example, it is definitely worth looking at Haribo® Tangfastics® under a UV lamp! A particularly interesting observation is that red and brown Smarties® are, to all intents and purposes, non-fluorescent when illuminated with UV light. By contrast, however, yellow and blue Smarties® are highly fluorescent and whilst yellow Smarties® fluoresce in the yellow part of the spectrum we were surprised to observe that blue Smarties® are pink when observed under UV illumination. Much has been written about the various colours of Smarties® (see for example [6, 7]) and in particular the history associated with blue Smarties®. It appears that the dye used to colour blue Smarties® is extracted from *Spirulina* – a possible investigation in the making?

Extending our researches into the drinks arena has been relatively disappointing with the exception of tonic water which when illuminated with UV light emits a blue fluorescence (Figure 7 and front cover); the molecule responsible for the

Fun with Fluorescence!



blue fluorescence being quinine. We did get quite excited after buying a bottle of Mountain Dew Energy® only to find that the yellow-green fluorescence we observed was from the plastic bottle rather than the drink itself!

The observation of fluorescence in tonic water allows us to adapt one of the most popular demonstrations - the so-called Diet Coke®/Mentos® eruption [8].

Explanations of the reactions which bring about the eruption have been well described in the literature [9, 10]. Briefly, nucleation sites on the surface of the Mentos® allow dissolved CO₂ to form bubbles and these are then rapidly released from solution.

A number of video clips of the demonstration exist but one of our favourites is the 'The Extreme Diet Coke & Mentos Experiments' [11]. Virtually any carbonated drink can be substituted for the Diet Coke® including tonic water [10].

So the tonic water/Mentos™ eruption is the basis for a beautiful demonstration in a room darkened except for a UV lamp (see Figure 7).

Our search for alternative carbonated drinks with different fluorescent properties continues; who knows one day we may be able to report on a fluorescent rainbow...



Figure 7 - Diet tonic water + Mentos®. Just visible at the top right hand corner of the photograph is the UV light source used as an illumination source.

What next?

In a future issue of the Bulletin we will report on how observation and measurement of fluorescence is providing new insights into structure and function in biological systems.

Curriculum links to CFE [12]

By exploring radiations beyond the visible, I can describe a selected application, discussing the advantages and limitations [SCN 3-11b].

By carrying out a comparison of the properties of parts of the electro-magnetic spectrum beyond the visible, I can explain the use of radiation and discuss how this

has impacted upon society and our quality of life [SCN 4-11b].

Equipment

Many of the experiments / activities described in this short article can be undertaken using portable UV lamps. If your budgets permit we would recommend the purchase of a large lamp such as an XX-40BLB manufactured by UVP (see www.uvp.com).

This lamp is available from a number of UK suppliers and the current catalogue price is of the order of £230. Such a lamp has many practical applications across the sciences.

References

- [1] Fluorescence - available at <http://en.wikipedia.org/wiki/Fluorescence> (accessed March 30th 2011).
- [2] How does hi-vis clothing work? – available at <http://www.brightkidz.co.uk/being-bright/how-hi-vis-works.html> (accessed March 30th 2011).
- [3] Moser S., Müller, T., Ebert, M-O., Jockusch, S., Turro, N.J. and Kräutler, B. (2008) Blue luminescence of ripening bananas, *Angew. Chem. Int. Ed. Engl.* 2008, **47**, 8954–8957.
- [4] MacCormac, A., O'Brien, E. and O'Kennedy, R. (2010) Classroom activity connections: Lessons from fluorescence, *J. Chem. Educ.*, **87**, 685–686.
- [5] Hodder, A.P.W. (2010) On Bananas, streetlights, and welding, *ChemED. NZ*, 120, 25.
- [6] Smarties – available at <http://en.wikipedia.org/wiki/Smarties> (accessed April 28th 2011)
- [7] Smithers, R. (2008) Smarties manufacturer brings back the blues – available at <http://www.guardian.co.uk/uk/2008/feb/11/fooddrinks> (accessed April 28th 2011)
- [8] Soda and candy eruption - available at http://en.wikipedia.org/wiki/Soda_and_candy_eruption (accessed April 2nd 2011).
- [9] Coffey, T.S. (2008), Diet Coke and Mentos: What is really behind this physical reaction?, *Am. J. Phys.*, **76**, 551-557.
- [10] Coffey, T.S. (2008), Soda Pop Fizzics, *Physics Teacher*, **46** 473-476.
- [11] The Extreme Diet Coke & Mentos Experiments – available at <http://www.eepybird.com/> (accessed April 2nd 2011).
- [12] Curriculum for Excellence: Sciences - Experiences and outcomes – available at <http://www.ltscotland.org.uk/learningteachingandassessment/curriculumareas/sciences/eandos/index.asp> (accessed 2nd April 2011).

SSERC Health & Safety

RF radiation risk – in whom should you believe?

The BioInitiative Working Group asserted [1] (2007) that adverse health effects have been demonstrated from exposure to radiofrequency (RF) fields at levels below current guidelines. “The entire basis for safety standards is called into question, and it is not unreasonable to question the safety of RF [energy] at any level.”

The above report was picked up by the media because it seemed newsworthy.



Figures 1a, b & c - Typical WiFi products: wireless router, laptop and digital enhanced cordless telecoms (DECT) phone.

It has been reported to us that some parents are concerned that RF radiation in Wi-Fi systems in schools may be harming the health of children. It would seem that these parents do not trust the safety limits on RF radiation set by the government. The RF radiation limits that apply here in the UK are ones recommended by international safety bodies and endorsed by the Health Protection Agency (HPA).

The scientific literature on RF bioeffects contains several thousand scientific papers. Review of this body of evidence takes special effort and expertise.

In contrast to the openness of the HPA are the methods used by some advocacy groups. If a group sets out to campaign on an issue then they have an agenda to stand by. Their minds tend to be closed to other views, or to evidence that is not to their liking. Campaign groups often purport to be scientific. Indeed they may comprise of groups of scientists. They are often arch sceptics and as scepticism is one of the qualities of science they can make themselves out to be saintlier than others, fighting to overturn perceived wrongs, or martyrs, having placed themselves outside the scientific consensus.

It is right that the level at which any public safety limit has been set is continually challenged by testing it against the evidence. But challenges have to be fair. It is sadly a fact that the challenges made by some campaign groups have been found to be unfair. The Guardian columnist and author of ‘Bad Science’, Ben Goldacre [2], has exposed many unfair practices – the MMR scare scandal being one.

In 2009 the journal ‘Health Physics’ published a report by the Committee on Man and Radiation (COMAR) [3] into the work of a group of scientists calling themselves the BioInitiative Group, authors of the BioInitiative Report (BIR), quoted from at the start of the article. COMAR found that the BIR had based its assertion on unfair means that the international safety limits of exposure to RF radiation could be dangerously high and should be lowered many-fold.

COMAR made the following criticisms of BIR:

1. The scientists who came together to form the BioInitiative group all believed at the outset that RF radiation is much more dangerous than is supposed by international and governmental authorities. Because of the fringe nature of the group, any decision they came to would be bound to be biased and unfair.

2. The evidence found to support the BIR findings had been cherry-picked. (It was based on one scientific experiment that had purportedly found a link between RF radiation and the induction of cancer in laboratory mice and another which linked DNA breaks in the brain cells of rats with RF.)

3. Repeats of both experiments by other scientists failed to find any evidence either for the development of tumours or damage to brain cells. They did find flaws in the original methods and one of the original experimenters has been investigated for scientific misconduct. In other words the BIR evidence had been based on poor science.

4. The BIR did not take on board the findings from many other experiments, nor the nullified results from the repeated attempts at the experiments they had regarded as crucial. It was selective and unbalanced.

BIR is an example of bad science. It unfairly sets out to show, by being highly selective in its choice of evidence, that RF radiation is more dangerous than the authorities declare it to be. It unfairly recommends that safety levels should be reduced by many orders of magnitude. It caused a public scare, which continues to sow mistrust in public bodies such as the HPA.

The BIR findings were widely reported in the press. They would have alarmed the public and sowed distrust on government safety levels and of the safety guidance being provided for the public by the HPA.



There is no reason to doubt the safety guidance issued by the HPA. It is staffed by independent scientists. Its guidance is for the public and for the government, but is independent of the government. HPA scientists work in an open manner, which is to say that they are open to evidence from any quarter.

In summary the expert scientific groups working under government auspices,

such as, in the UK, the HPA, and, internationally, WHO and ICNIRP, are to be trusted. They work by fair means in an open manner.

They conduct original scientific work, which is peer reviewed, and carry out reliable reviews of the scientific evidence from other studies. There is no reason not to place confidence in our scientific public bodies.

The guidance on Wi-Fi radiation currently issued by the HPA [4] states "On the basis of current scientific information, exposures from Wi-Fi equipment satisfy international guidelines.

There is no consistent evidence of health effects from RF exposures below guideline levels and no reason why schools and others should not use Wi-Fi equipment."

References

- [1] BioInitiative Report: <http://www.scribd.com/doc/9394830/Bioinitiative-Report-on-Health-effects-of-EMF-ELF-radio-frequency#fullscreen:on>
- [2] 'Bad Science', Ben Goldacre, Fourth Estate, 2008, ISBN 978 0 00 724019 7.
- [3] COMAR Technical Information Statement: Expert Reviews on Potential Health Effects of Radiofrequency Electromagnetic Fields and Comments on the BioInitiative Report, Health Physics: October 2009 - Volume 97 - Issue 4 - pp 348-356
- [4] <http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/UnderstandingRadiationTopics/ElectromagneticFields/WiFi/>

Secure storage of chemicals



The Home Office is in the process of setting up a programme called *Secure Your Chemicals*, aimed at ensuring all holders and users of particular hazardous chemicals have effective systems to manage and monitor their stock. This applies to schools as well as industries and SSERC (together with

CLEAPSS in England), is working with the Home Office to produce some appropriate guidance.

This guidance is likely to confirm existing SSERC advice and should not, therefore, present any issues to well-

run science and D&T departments. The guidance will be made available on the SSERC website in a few months time, as soon as it is clarified, and schools are urged to look out for it.

It would be a good idea for schools to plan to carry out a thorough audit of

existing chemical stocks during the coming summer. We believe that a thorough audit could be timely in many respects but it will certainly allow schools to be confident that they meet the intentions of this programme. Remember, you can always contact us here at SSERC to resolve any issues an audit might raise.

The programme is likely to be publicised through a number of routes so you may find some local authority representatives or school governors enquiring about what actions schools might need to take.

Used-battery fire

We have had a report of a fire in a used-battery recycling container in the stores of a government laboratory. The fire was put out using fire fighting appliances before the fire service arrived on site, but things would have been worse if the incident had happened outside of working hours.

The cause seemed to be disc-shaped lithium batteries short circuiting and generating heat.

Our advice is to prevent short circuits by wrapping insulating tape over terminals, or by doing a one-for-one swop by putting the old battery into the packaging the new battery comes out of and marking the package "USED – FOR DISPOSAL".

Of most importance - do not take new batteries out of their packaging and store them one on top of the other in a nice neat pile.



SSERC Technology Roundup

Safe use of woodworking machinery - Approved Code of Practice and Guidance

Up until now, the Safe use of woodworking machinery, 'Approved Code of Practice and Guidance' (ACOP) has only been available to buy as a book from the HSE (Health and Safety Executive) [1].

This ACOP was prepared by the Health and Safety Executive (HSE) after consultation with industry. The advice given in the Approved Code of Practice (ACOP) and guidance reflects the precautions that are widely accepted and used to reduce risks from woodworking machinery.

The ACOP contains the Provision and Use of Work Equipment Regulations 1998 that are relevant to the safe use of woodworking machinery, together with an Approved Code of practice and supporting guidance. The document covers the provision of information as well as aspects of guarding, machine stop controls, warnings, markings and maintenance and is aimed at those who have responsibility and/or control use of woodworking machinery either directly or indirectly.

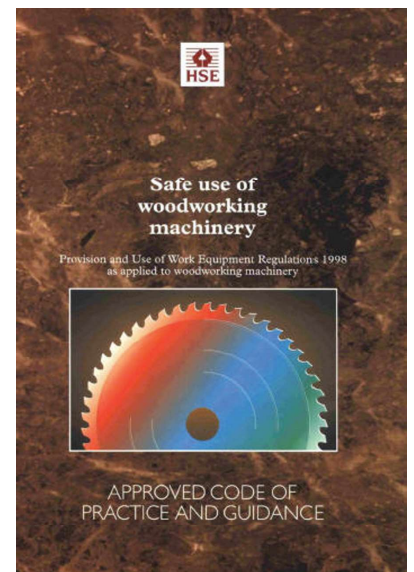
The HSE report that the woodworking industry has one of the highest accident rates in manufacturing, most of which are caused by contact with moving machinery. It is therefore good news that, Safe use of woodworking machinery, 'Approved Code of Practice and Guidance' (ACOP), which forms part of the range of topics covered in the HSE guidance for the woodworking industry [2] and gives advice on some of the precautions to ensure the safe use of woodworking machinery, is now free to download via the HSE website [4].

In many respects this document is a daily guide to safe working practice for woodworking machinery. No school technology department should be without one.

References

- [1] *Safe use of woodworking machinery, Approved Code of Practice and Guidance (L114)*, ISBN 978 0 7176 1630 5, £8, www.hsebooks.co.uk
- [2] <http://www.hse.gov.uk/woodworking/>
- [3] http://www.hse.gov.uk/pubns/indg_291.pdf
- [4] <http://tinyurl.com/SUWM-ACOP>

The Code of Practice relates directly to current health and safety legislation i.e. the Provision and Use of Work Equipment Regulations 1998 (PUWER98) [3]. It has a wealth of information regarding training, machine stop controls, warnings, markings, maintenance, and much more. The use of correct guards and push stick design is also covered.



Designing cut-outs using arcs

Whether using CAD or working with a pencil in the workshop, the following formulae take the guesswork out of arc cut-outs on designed products. How often do we cut an arc into materials using two end points at an edge? The use of paint tin lids springs to mind, carefully drawing around it, with little thought of 'radius' or 'height' of the arc into the material.

Consider:

L = the length of arc on the product.
H = the maximum height of the arc into the material (rise of the arc)
R = the radius of the arc

1. Given length (**L**) across the arc and the height of the arc (**H**), what is the radius of the arc?

$$R = H/2 + L^2/8H$$

2. Given the radius of the arc (**R**) and the length (**L**) across the arc, what is the rise/height of the arc?

$$H = R - \sqrt{R^2 - L^2/4}$$

3. Given radius (**R**) and height (**H**), what is the length (**L**) across the arc?

$$L = \sqrt{4R^2 - 4(R-H)^2}$$

The three formulae may be incorporated into a spreadsheet, providing a quick and easy arc calculator. The formulae have already proved useful when looking at sketches and drawings without

dimensions, in particular the determining of the arc centre and radius from measuring the length of arc and height/rise of arc from the drawing.

A spreadsheet is available for download from the SSERC website.

