



SSERC Bulletin

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Ideas and Inspiration supporting Science & Technology for all Local Authorities

Toilet Tissue Challenge

*Dye-Sensitised
Solar Cells – Part 2*

Quantum Efficiency

Health & Safety

Conference Report

Introduction

In a small study reported in the British Medical Journal [1], only one third of all men and one half of women washed their hands after using the toilet. The most common way microbes are spread is via people's hands. Whilst these microbes are often harmless, they can cause illnesses such as colds, flu, sickness and diarrhoea, as well as spreading infections with more serious consequences such as winter vomiting virus, MRSA, *E. coli* 0157, and *C. difficile* in hospitals. Hand washing is thought to be the single most important thing anyone can do to help reduce the spread of infections. It takes a minimum of fifteen seconds to wash hands thoroughly to remove all infectious agents, which is about the time you would take to sing 'Happy Birthday to you' twice [2].

Scotland's National Hand Hygiene Campaign is being delivered by Health Protection Scotland, on behalf of the Scottish Government Health Directorate [2]. Its core aim is to improve hand hygiene and to reduce avoidable illness. The high profile campaign is aimed at the general public and health practitioners both in their daily lives and when in hospital as visitors, patients or at work. All hospitals now have alcohol-based hand rubs at the entrance to each ward, and most people are aware of the need to use them. However, these hand rubs are ineffective against *C. difficile* which can only be effectively removed by proper washing with soap and water (2).

This practical addresses the problems associated with poor hand hygiene in a fun way, with a definite 'eugh-yuk' factor which we hope will appeal to teenagers, while getting across a very important message.

More specifically, the practical can be used to investigate:

- i. The transmission of microorganisms through toilet tissue
- ii. The effectiveness of hand washing in removal of microorganisms

Procedure

This experiment would work equally well as an individual investigation or with pupils working in pairs or groups of three.

Materials for each pupil/group

- YGA¹ plates, x2
- dried bakers yeast
- Universal or similar small bottle
- spatula
- disinfectant- Virkon™, or similar
- tap water
- toilet tissue
- cleaning solutions – hand wipes, soap, alcohol rub etc.
- pens for labelling

¹YGA plates contain a nutrient-rich medium that provides everything yeasts need to grow [3].

Method

Add approximately 0.1 g dried yeast (a small spatula full) to the universal, and add around 3 cm³ of fresh tap water. Shake well until the yeast is fully suspended, and then pour onto one of the YGA plates. This is plate 1. Pour off excess liquid into the disinfectant, and discard the universal bottle into disinfectant. This plate is the 'model bottom' (or should it be 'bottom model'?) and the yeast is acting as a model for bacteria which might be found in faecal material. Label the second plate with initials, date and tissue brand and details of investigation (varying one of the factors as discussed below). Divide the plate into four and number the segments 1-4 (Figure 1). This is plate 2. To simulate the normal use of toilet paper, first start by washing your hands well and dry them in your usual manner. Wrap a piece of toilet paper around a forefinger and draw it across Plate 1 (the plate flooded with yeast). Remove the toilet tissue and discard, then roll your forefinger gently but firmly from side to side over section 1 of agar plate 2 (see Figure 2). Wash this finger with either plain water or one of the cleaning agents, dry thoroughly, and then roll it gently but firmly over section 2 on the plate. The whole process can then be repeated in segments 3 and 4 to investigate the effects of changing one factor (see below). Plates should be sealed diametrically with two small pieces of tape and then incubated base uppermost at room temperature for 2-3 days.

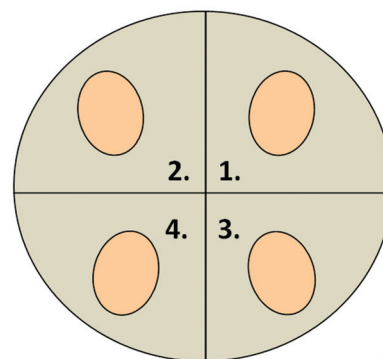


Figure 1

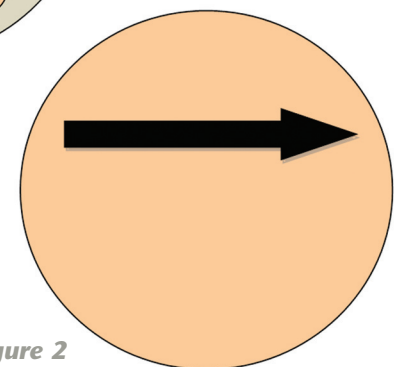


Figure 2

Factors which could be investigated include:

- type of toilet tissue or other household tissues
- number of layers of tissue
- type of cleaning agent, including washing with water alone
- length of time taken to wash fingers

Results

We present results from a variety of investigations. For each plate, section 1 shows the finger roll before washing, 2 shows the finger roll after washing, and 3 and 4 are replicates.

Figure 3 shows that yeast cells can go through one layer of Andrex™, and that they can also remain on the fingers after washing with water.

Figure 4 shows that fewer yeast cells get through two layers of Andrex™, although some can still survive washing with water.

Figures 5 and 6 show that yeast cells travel through two layers of Andrex™, but are removed by washing with the Matron™ or Tesco gel cleanser.

Figures 7 and 8 give results from IZAL™ toilet tissue.

Figure 7 shows that yeast can go through one sheet of IZAL™, and survives washing with water, and Figure 8 shows that yeast can get through two IZAL™ layers. Overall the results show that yeast cells can travel through toilet paper and can also survive washing with water. Our results show that washing with a cleanser removes the yeast.

Plates should not be opened when results are taken, and should be autoclaved before disposal with normal rubbish [3].

Discussion

A major surprise to most people is that the yeast can pass through one or more layers of toilet tissue, and survive some washing. However, once the size of the individual yeast cells and the structure of most toilet tissues are considered, it is perhaps not so surprising. Teachers may want to ask pupils to compare the size of yeast cells to faecal bacteria, and what this could mean in terms of the ease of bacterial transfer. A recent study by researchers from the London School of Hygiene and Tropical Medicine found that overall one in four of people surveyed had some faecal bacteria on their hands [4]. Class results will lead to a lively discussion of current and future behaviour, and will highlight the importance of hand hygiene after a visit to the toilet. Finally, pupils should be encouraged to wash their hands at the end of the practical – perhaps using the guidelines on hand washing from washyourhandsofthem.com, while singing two rounds of 'Happy Birthday to You'.

How does the practical fit into the Curriculum for Excellence?

This practical is suitable for use in many ways, and at different levels. It could easily be incorporated into a cross-curricular study into health and hygiene for first and second year pupils. This could address EO's SCN 3-13b, and SCN 3-20b from Science, and Health and Well Being HWB 3-16a, HWB 2-33a, HWB 3.33a [5]. It could also be used as a full investigation to help the development of scientific inquiry and investigative skills. There is also the potential for development into an Advanced Higher Biology Investigation.

This practical was originally developed for use with undergraduate students at the University of Strathclyde and we are grateful to staff from the University for sharing it with us.

References

1. BMJ.COM (Register free for access to articles)
2. www.washyourhandsofthem.com
3. www.sserc.org – Microbiological Techniques
4. www.ishtm.ac.uk/news/2008/dirtyhandsstudy.html
5. www.science3-18.org/index.php?option=com_content&view=article&id=657&Itemid=16

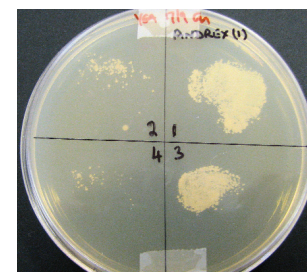


Figure 3

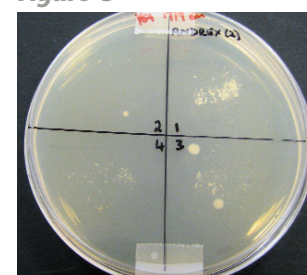


Figure 4

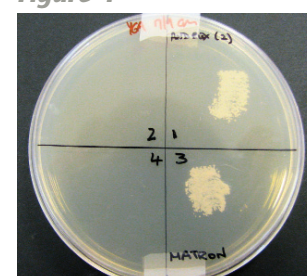


Figure 5

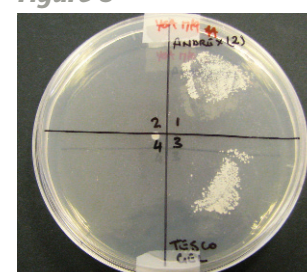


Figure 6

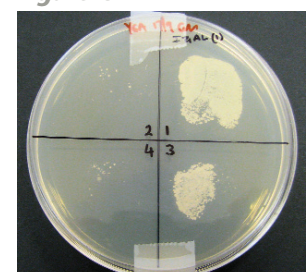


Figure 7

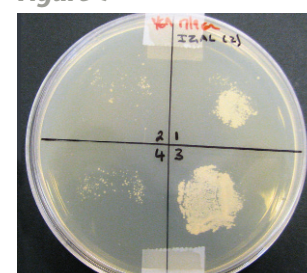


Figure 8

The first part of this subject described the Man Solar kit which can be used to produce dye-sensitised solar cells (DSSCs). These cells use a dye which directly converts the energy of sunlight into electrical energy using a process which, in some aspects, is similar to photosynthesis. Conventional solar cells are rather expensive owing to the cost of producing high grade silicon. In contrast, DSSCs use a nanocrystalline layer of titanium dioxide making them much cheaper to construct. This titanium dioxide layer acts both as a matrix for the photon-capturing dye molecules, and as a wide band-gap semiconductor.

This part describes some of the results obtained when various natural dyes were tested as photon-receptors, and the pH dependency. It also looks at the regeneration of the electrodes, and describes how to produce new titanium dioxide coated electrodes. Lastly there are suggestions of where this new technology could be incorporated within the 3-18 framework.

Testing sources of natural dyes

Several dyes have been prepared from plant material to compare their efficiencies. These include: fresh blueberries; hibiscus flowers (supplied in the kit); red cabbage; red onion skins; red capsicum (sweet pepper); and fresh spinach leaves. Beetroot has not been tested as it is reported that the dye will not absorb onto the titanium dioxide layer. The purple pigment in beetroot is a betalain, and not an anthocyanin, which may explain this observation.

In each case 10 g of chopped material was added to 50 ml of boiling water and left until cool. The cold dye solution was poured into a Petri dish and the titanium dioxide coated electrodes were left to soak in the dye for 10 minutes.

Dye source	Dye colour	Output current (mA)
Blueberries	purple	0.113
Hibiscus flowers	deep red	0.219
Red cabbage	deep purple	0.085
Red onion skins	deep red	0.050
Red capsicum*	pale orange	0.002
Spinach *	pale green	0.016

Table 1 - Sources of natural dyes and their solar cell output currents.

As the dye obtained from the Hibiscus 'flowers' produced the greatest current, it was therefore a more efficient solar cell than any of the other natural sources being tested. It is assumed that the dye probably contains a mixture of flavonoids.

* The dyes from red capsicum and spinach have also been extracted using ethanol. Although this results in a dye colour of much deeper intensity, there is no corresponding improvement in the output current from the consequent solar cells.

These are based on glycosylated (i.e. sugar-linked) anthocyanidins (Figure 1) which have the following general structure:

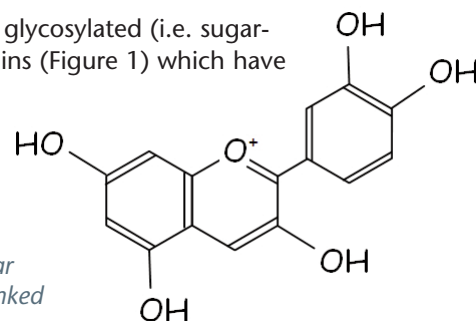


Figure 1 - Molecular structure of sugar-linked anthocyanidin.

The most important of these are: pelargonidin which gives the orange-red colour to geraniums, raspberries and strawberries; cyanidin which produces the magenta of ripe blackcurrants and red cabbage; delphinidin gives the blue colour to delphiniums and violas; and peonidin, which provides the purplish-red of peonies and cranberries. Flavonoids are also associated with antioxidant properties.

Possibly these compounds could be separated by chromatography to see which component in the mixture was the most effective in the solar process i.e the active ingredient.

It has been suggested that dye uptake by the titanium dioxide layer is improved by using a hot dye solution, but no evidence has been found to support this claim when red cabbage was used as the dye. Other dyes, of course, may behave differently and this might be worth investigating.

Testing the effect of pH

Most of the anthocyanins are pH sensitive. For example, the pigment that gives the intense blue colour to cornflowers in basic conditions is also responsible for the red colour of poppies in acidic conditions.

In schools, red cabbage is commonly used as a source of pH indicator dye. In conditions where the pH is below 3, this dye turns a pinkish red, whereas above pH 11 the dye turns a deep blue-green.

If a few drops of 0.1M hydrochloric acid or 0.1M sodium hydroxide are added to the surface of the titanium dioxide layer which has already been impregnated with the red cabbage dye, there is an immediate colour change.

When these electrodes were rinsed with distilled water and assembled as solar cells, it was found that the output current at pH 7 was higher than at pH 1 or pH 13 (Table 2).

pH of cabbage dye	Dye colour	Output current (mA)
1	dark pink	0.048
7	deep purple	0.083
13	dark green	0.015

Table 2 - The effect of pH on the output current of a red cabbage solar cell.

Similar results are obtained when undyed titanium dioxide electrodes are soaked in the cabbage dye at the three pH values, rather than changing the pH after the cabbage dye has been absorbed into the titanium dioxide layer.

It seems likely that not only is there a decrease in the efficiency of photon capture by the cabbage dye at extremes of pH, but also that the ability of the dye to adhere to the titanium dioxide layer is impaired.

Synthetic DSSC dyes

It is essential that the dyes used in commercial solar cells do not degrade even after years of exposure to the extremes of sunlight, and there is considerable research taking place to develop suitable synthetic dyes.

Most of the commercially, synthetic dyes which have been developed so far, contain transition metals and ligand complexes. A good example of this is Ruthenium 505 (Figure 2).

Chemical name: *cis*-bis(cyanido) bis(2,2-bipyridyl-4,4-dicarboxylato) ruthenium (II)

Its manufacturers claim that Ruthenium 505 efficiently sensitizes wide band-gap oxide semiconductors, like titanium dioxide, up to a wavelength of 650 nm. As it has excellent stability properties, Ruthenium 505 is suitable for photochemical experiments and solar cell arrays.

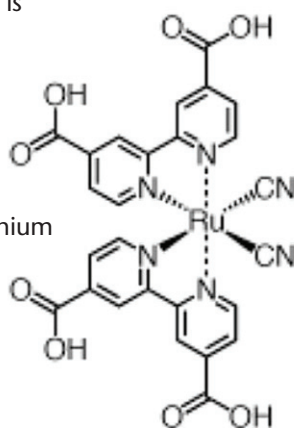


Figure 2 - Ruthenium 505

Regenerating the electrodes

The graphite coated electrodes can be reused, without any loss of efficiency, merely by rinsing off the old electrolyte and leaving them to dry. Once dried, a fresh layer of graphite can be applied if it is deemed to be necessary.

Regeneration of the titanium dioxide coated electrodes does not appear to be quite as simple. The dye can easily be removed from the titanium dioxide layer by soaking in cold water, or by pouring boiling water over the electrode (Table 3).

Method used to wash TiO ₂ electrode	Output current after washing (mA)
Unwashed (control)	0.196
Overnight in water at room temperature	0.006
30 minutes in water at room temperature	0.007
2 minutes in boiling water	0.007

Table 3 - The effect of washing procedures on the removal of Hibiscus 'flower' dye, using the residual output current as an indicator of effectiveness.

However, the electrodes show a reduced ability to reabsorb the Hibiscus dye, as shown by the data obtained when a solar cell was repeatedly reassembled with the titanium dioxide electrode being washed in boiling water, dried, and re-dyed, between each cycle (Table 4).

Age of TiO ₂ electrode (cycle)	Output current (mA)	Re-use Efficiency (%)
1st	0.223	100
2nd	0.121	54
3rd	0.082	37
4th	0.046	21

Table 4 - The ageing effect on the titanium dioxide electrode in a Hibiscus 'flower' solar cell.

Making new titanium dioxide coated electrodes

The titanium dioxide suspension is prepared by the incremental addition of 10 ml of very dilute ethanoic acid to 5 g nanocrystalline titanium dioxide powder (e.g. Aeroxide TiO₂ P25) while it is being ground with a mortar and pestle for 10 minutes. It should be noted that ordinary titanium dioxide will not adhere to the glass when sintered. Finally, adding one drop of dishwashing detergent and mixing again should produce a smooth paste.

Prior to coating the glass electrodes with titanium dioxide, they are attached on three sides to a white tile using adhesive tape, making sure that the conductive side is uppermost. A 3 mm wide strip holds the electrode on both sides and a 5 mm wide strip holds the top end.

One drop of the titanium dioxide slurry from a Pasteur pipette is then added at the top end of the electrode, and gently drawn down the glass surface using a glass rod which is resting on the two side strips of adhesive tape (Figure 3). This should produce a uniform thin layer.

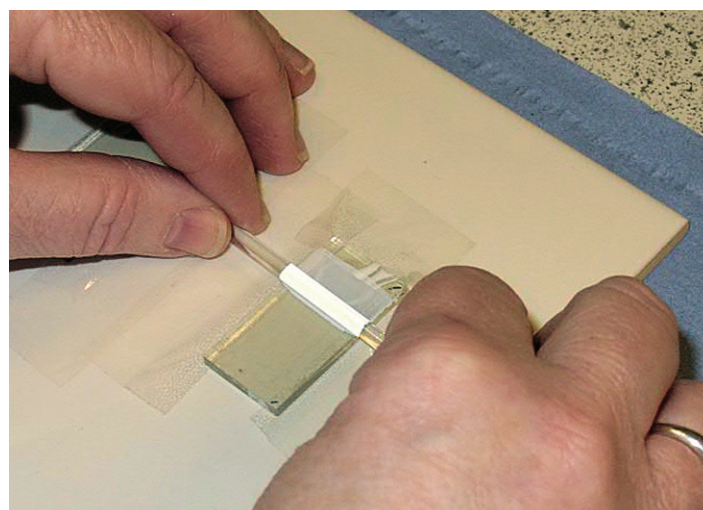


Figure 3 - Applying the titanium dioxide layer to the glass electrode

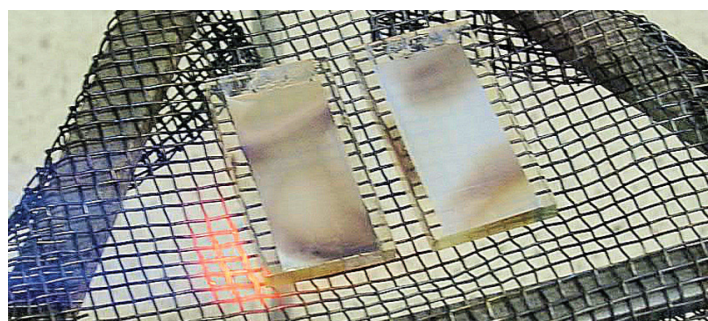


Figure 4 - Sintering the titanium dioxide layer with the blue flame of a Bunsen burner.

After the coating has dried (a hair-drier speeds up this process), the adhesive tape is removed and the electrode is placed on a wire gauze for sintering. As a blue Bunsen flame is passed slowly over the titanium dioxide surface, it turns dark brown and then goes white. This process only takes about 3 minutes (Figure 4).

After sintering, the coated electrode must be allowed to slowly cool to room temperature, otherwise the glass is liable to crack or shatter.

Sources of material

Most of the items in the Man Solar 2000 kit will already be in schools or can be purchased locally. However it might be considered prudent to purchase a kit which is proven to work, before attempting to substitute in alternative materials which may, or may not, work equally well.

Hibiscus 'flowers', Hibiscus tea or 'Flor de Jamaica' can be purchased in many health food stores. Alternatively dried Hibiscus flowers can be purchased on the internet for about £2 per 100 g (e.g. www.Mexgrocer.co.uk) or by post from: MexGrocer, 1 Tennyson Rd, Stockport, SK5 6JJ. Tel : 0800 849 9042 (Information Line Only)

The tri-iodide electrolyte can be prepared by dissolving 0.127 g iodine (I₂) in 10 ml of ethane 1,2-diol (ethylene glycol – Harmful vapour) and then adding 0.83 g potassium iodide. The solution should be thoroughly stirred and stored in a dark container.

Hazards and control measures

Chemicals & procedures	Main Hazard	Control Measures
Iodine/tri-iodide electrolyte incl. ethane-1,2-diol	Harmful	Wear nitrile gloves and indirect vent goggles.
Glass electrodes (assembling solar cell)	May have sharp edges and may break if pressed too hard.	Hold glass electrodes carefully and add bulldog clips gently.
Glass electrodes (sintering of titanium dioxide)	May shatter if heated and cooled too rapidly.	Heat on a wire gauze and leave to slowly cool.
Boiling water for dye-bath	Scalding	Don't touch or move beaker containing the boiling hot dye-bath.

Table 5 - Hazards and control measures.

Electrically conductive glass is produced in Britain as Pilkingtons K Glass™ (4 mm). A single sheet of glass (30 cm x 30 cm) could be cut by a glazier to produce over 100 electrodes (2 cm x 4 cm). To minimise the risk of fingers being cut by sharp glass, the sides of each glass electrode should be passed through a hot Bunsen burner flame.

Pilkingtons K Glass™ appears to be the same as Pilkingtons TEC Glass™ (Transparent Electrically Conductive Glass) which is produced by Pilkingtons in the United States.

Nanocrystalline titanium dioxide powder (e.g. Aeroxide TiO₂ P25) is available from various chemical suppliers.

Man Solar also sell the following single materials but there is a minimum order charge:

Article 001: One set contains 6 titanium dioxide coated conductive glass electrodes and 6 conductive glass electrodes.

Article 002: One set contains 12 conductive glass electrodes. These are ready to be sintered with titanium dioxide or coated with graphite.

Article 004/005: Titanium dioxide solution to be deposited and sintered onto article 002

Article 013: Dried Hibiscus flowers

MAN SOLAR B.V., Westerduinweg 3, 1755 LE Petten, The Netherlands

E-mail: mansolar@ecm.nl. Internet: <http://www.mansolar.com>

Linking to Curriculum for Excellence – Experiences and Outcomes

There are a number of ways in which dye-sensitised solar cell technology could be incorporated into science learning and teaching, and some of the opportunities are illustrated below. It could also provide the focus for inter-disciplinary links with a cross curricular theme, as well as encouraging the principles and practice of "A Curriculum for Excellence". Shorthand links to the www.science3-18.org website are also shown [].

The Sciences, Materials, Properties and uses of substances, **SCN 4-16a** Researching novel materials

I have carried out research into novel materials and can begin to

explain the scientific basis of their properties and discuss the possible impacts they may have on society.

[<http://tinyurl.com/SCN-4-16a>]

Activities which could link to this outcome:

- i. Build a DSSC.
- ii. Compare 3 or 4 different plant dyes, including beetroot to show that not all coloured dyes work.
- iii. Add solar cells together in series and use a multimeter to find out the voltage required to operate a pocket calculator or melody module.
- iv. Research the use of cheap DSSCs in developing countries where there is no National Grid.

The Sciences, Planet Earth Energy sources/sustainability, **SCN 2-04b** Exploring non-renewable energy sources
Through exploring non-renewable energy sources, I can describe how they are used in Scotland today and express an informed view on the implications for their future use.

[<http://tinyurl.com/SCN-2-04b>]

The Sciences, Planet Earth, Energy sources/sustainability, **SCN 3-04b** Issues with renewable energy

[<http://tinyurl.com/SCN-3-04b>]

By investigating renewable energy sources and taking part in practical activities to harness them, I can discuss their benefits and potential problems.

Technologies, Tech. developments in society, TCH 2-02b Renewable & sustainable energy

[<http://tinyurl.com/TCH-2-02b>]

I can investigate the use and development of renewable and sustainable energy to gain an awareness of their growing importance in Scotland or beyond.

Activities which could link to this outcome:

- i. Build a DSSC.
- ii. Compare 3 or 4 different plant dyes, including beetroot to show that not all coloured dyes work.
- iii. Back the solar cell with reflective foil to see if the output current is increased.
- iv. Plot the relationship between output current and light intensity (by measuring the distance from a light source or using a light meter).

The Sciences, Topical science, **SCN 4-20a** Current and future developments

I have researched new developments in science and can explain how their current or future applications might impact on modern life.

[<http://tinyurl.com/SCN-4-20a>]

Activities which could link to this outcome:

- i. Build a DSSC
- ii. Compare the output currents of a DSSC and a silicon solar cell at different light intensities.

- iii. Research future applications – providing energy in developing countries when there is no opportunity to recharge them through a national grid. (e.g. LED lighting, radios, refrigerators, water purification, mobile phone rechargers).

The Sciences Planet Earth Energy sources/sustainability

SCN 4-04a Risks and benefits of energy

By contributing to an investigation on different ways of meeting society's energy needs, I can express an informed view on the risks and benefits of different energy sources, including those produced from plants.

[<http://tinyurl.com/SCN-4-04a>]

Activities which could link to this outcome:

- i. Build a DSSC
- ii. Compare the DSSC to another renewable source of energy in terms of cost, energy output, reliability and level of technology required to build it.
- iii. Discuss attitudes towards “green energy” sources such as solar cells, wind turbines and bio-fuels.

The Sciences, Forces, electricity & waves, Electricity,

SCN 4-09a Current, voltage and resistance

Through investigation, I understand the relationship between current, voltage and resistance. I can apply this knowledge to solve practical problems. [<http://tinyurl.com/SCN-4-09a>]

Activities which could link to the first part of the outcome:

- i. Build a DSSC
- ii. Add a variable resistance across the DSSC and plotting the relationship between voltage and current.
- iii. Plot the relationship between power and voltage, to find the maximum power point.
- iv. Use these graphs to examples of appliances which would / would not operate using a DSSC.

Open-ended Investigation Projects

As pupils will be unfamiliar with dye-sensitised solar cells they have tremendous potential as the basis of open-ended investigations.

Possible starter questions might include:

- i. Which flower petals produce the most effective dye for a DSSC?
- ii. Is there a significant degradation of the dye over a period of time, as shown by a decrease in the output current? (The student would need to ensure that it is not just the electrolyte drying up)
- iii. Is dye degradation accelerated by increasing the intensity of light?
- iv. Does the ionic environment (concentration and type of ions) affect the photon-trapping efficiency of the dye?
- v. Can the mixture of anthocyanidins in a plant extract dye be separated (e.g. by chromatography) to see which is the most effective component?

Counting photons

After several calls for help from teachers of AH students who had been trying to measure the power of a laser by irradiating a thermistor and looking for a change in resistance we thought surely there must be a better way with equipment that's readily available or components that are inexpensive. So we thought of photodiodes and came to see that this is a good way of consolidating quantum theory with classical effects.

Here is a method for counting the photons in visible radiation. When a PIN (or p-i-n) photodiode is irradiated with light, photons absorbed in the depletion or intrinsic region produce electron-hole pairs, most of which result in a photocurrent I of n_e electrons/second. If the radiant power¹ P and wavelength λ of the radiant source are known and if the area of the photodiode is large enough to intercept all of the emissions, then the rate of flux of photons n_{ph} hitting the photodiode can be found. The ratio of these two values η is the quantum efficiency.

$$\eta = (n_e/n_{ph}) \times 100\%$$

The quantum efficiency of a photodiode can be very high indeed (95%) and depends on wavelength. Photodiodes made of silicon have a good spectral response between 400 and 1000 nm, and work best around 800 to 900 nm.

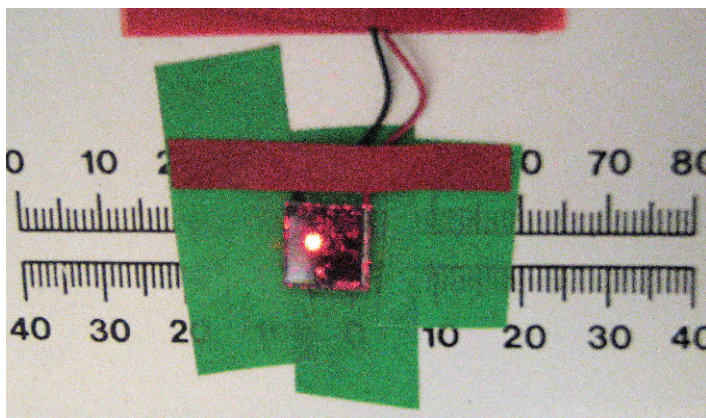


Figure 1 - Closeup of large-area planar photodiode

To find the quantum efficiency, your radiation source should be monochromatic, or nearly so, and produce a narrow beam of diameter under 7 mm. Either a laser or narrow-beam LED is suitable. If using a LED, the LED should touch the centre of the photodiode, ensuring that none of its emissions miss.

In our method, radiant power was measured with a photometer (Edmund, J54-038, £139.30). Unless you have such an instrument you will need to look at the technical specification of the source to find what its radiant power is. If you do not know what it is for your laser, then, since the laser ought to be a Class 2 product, its power will be less than 1.0 mW.

¹ The proper symbol for radiant power is ϕ rather than P .

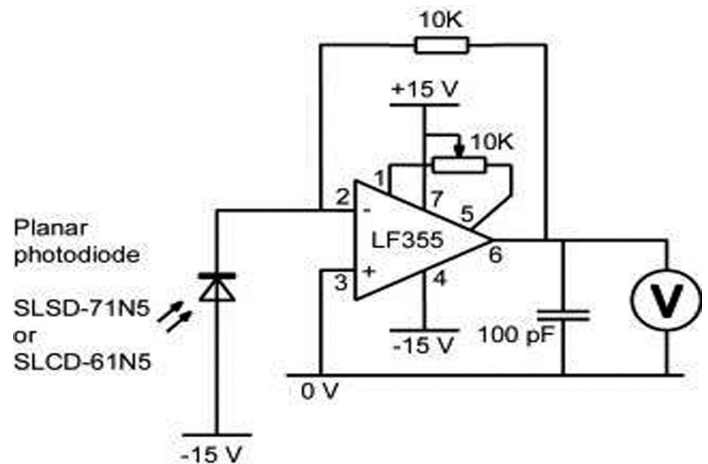


Figure 2 - Circuit to convert a photocurrent to a voltage [1].

If using LEDs the brightness of visible LEDs is normally specified in luminous intensity in units of millicandela (mcd). This is the radiating power of a source of light in a particular direction. This quantity is used because LED radiation is highly directional and is weighted with the spectral sensitivity of the eye. The conversion to radiant power is explained on our website. For infrared LEDs, the output is specified differently in either radiant power (mW), irradiance (mW/cm²), or radiance (mW/sr).

The photodiode should have a large area (Fig. 1). We recommend the Silonex planar photodiode SLCD-61N5 (Farnell, order code 121-8990, £11.26) [1].

This has a slab of p-type silicon sitting on a similar-sized slab of n-type, 10 mm square, with intrinsic silicon sandwiched between. It is wired to a current-to-voltage converter, with an LF355N JFET op-amp (Fig. 2). The conversion rate ($I = V/10,000$) is set by the 10 k feedback resistor. If this has the usual 5% tolerance, the uncertainty is 5% also unless you measure it.

If e is the electron charge, the number of photocurrent electrons/second n_e is given by

$$\begin{aligned} n_e &= I/e \\ &= V/10,000e \end{aligned}$$

The energy of a photon is hc/λ where λ is the radiation wavelength, h is Planck's constant and c is the speed of light. Therefore the number of photons per second n_{ph} from a source of radiant power P and wavelength irradiating the photodiode

$$\text{is } n_{ph} = P\lambda/hc$$

The quantum efficiency η is

$$\eta = (Vhc/10,000eP\lambda) \times 100\%$$

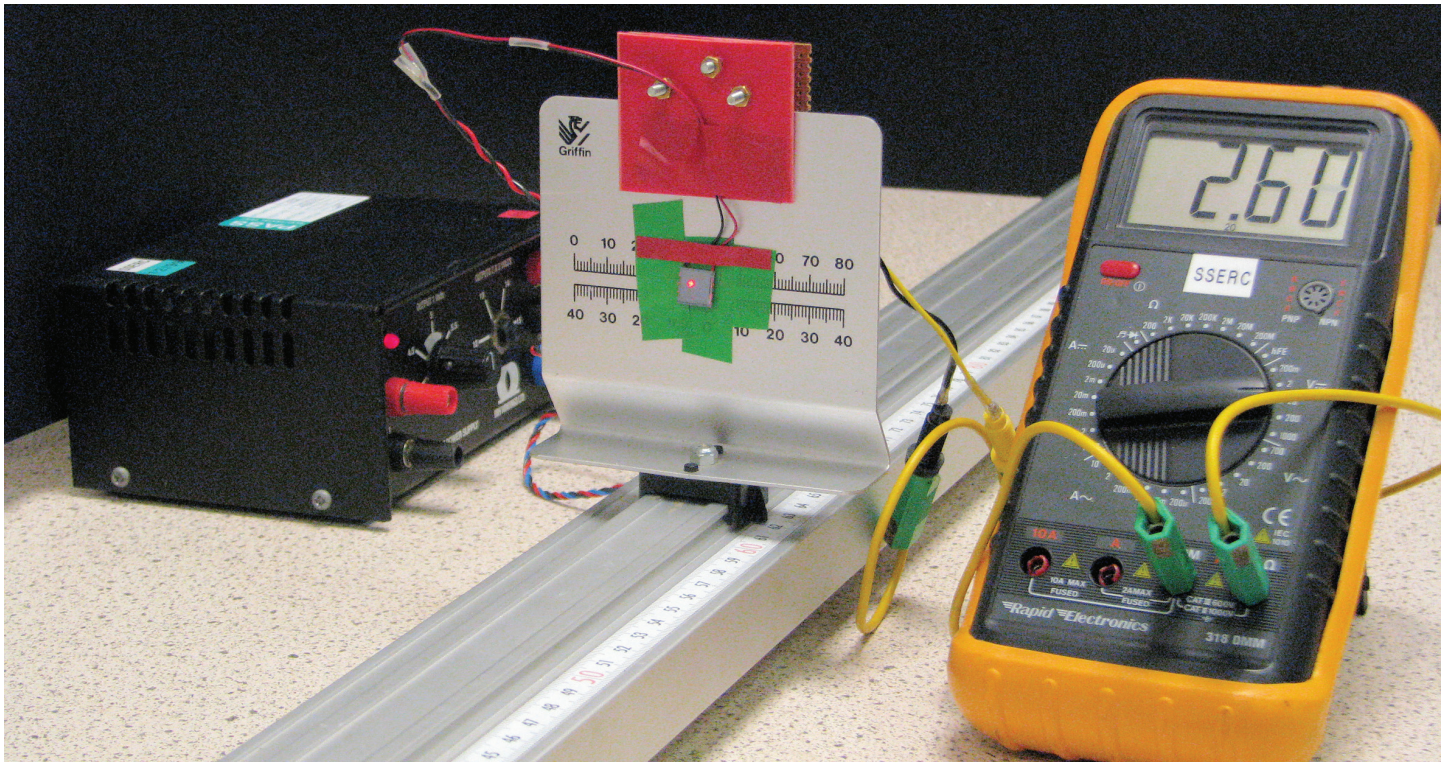


Figure 3 - Large-area planar photodiode irradiated with laser radiation.

The quantum efficiency of the photodiode has been found with several light sources (Table 1) and lies between 60 and 70% ($\pm 13\%$). It is less than 100% for several reasons – reflection at the surface, absorption within the doped silicon before the depletion region can be reached and the recombination of electrons and holes. Tabulated values of radiant power from laser sources (marked with an asterisk) have been corrected for reflection. Reflections with LED sources were impossible to correct for, but as the LED's lens was hard against the photodiode, there would have been multiple reflections to and fro between the surfaces such that perhaps not too much light was lost.

Discussion

Although we have written up this report as one of finding the quantum efficiency of a photodiode, this concept is of little interest in itself. The main purpose is to show agreement

between an irradiation of photons and the generation of current that this gives rise to. Thereby two theoretical strands, photon energy (hf) and electric charge ($n_e e$), and two measurable quantities, radiant power and electric current, are both shown to be bound up together, cause and effect. The agreement is one of an inequality – there are always more photons than electrons. Knowing the rate of production of current, you have a means of counting photons.

The method lends itself to an Advanced Higher Physics investigation, perhaps being turned round to that of finding the radiant power of a laser or an LED.

Source	HeNe laser	Green laser diode module	Green LED	Blue LED
Product details	Griffin XfV-540-010V	Roithner CW531-001	Rapid 55-1668	Rapid 55-1490
Wavelength λ (nm)	633	532	525	470
Radiant power P (mW)	0.71*	0.51*	0.506	0.385
Voltage output V (V)	2.40	1.44	1.40	1.00
Photocurrent I (mA)	0.24	0.14	0.140	0.100
Quantum efficiency η (%)	66%	66%	66%	69%

Table 1 - Values of wavelength, radiant power & photocurrent used to derive quantum efficiency of a photodiode

Reference

[1] Laser radiation sensor, SSERC, Bulletin 201, 2001.

Unsafe chargers

The Electrical Safety Council warns that millions of unsafe AC/DC plug-in chargers are being imported into the UK every year, mainly from China. These chargers are being sold, often through the internet, for use with mobile phones, games consoles, cameras and portable music players.

Following an incident where a child narrowly escaped electrocution, Buckinghamshire Trading Standards [1] looked at samples of 36 chargers obtained from a range of outlets. The results are alarming. Only branded products, 12 in all, complied with the regulations. As for the unbranded chargers, all 24 failed for reasons of poor internal construction. Moreover the plug pin-size and positioning on the unbranded chargers were not right, leading to a risk of overheating and fire when plugged into a 13 A socket-outlet.

The message we take from this is that branded chargers supplied by major manufacturers of electronic goods do generally conform to standards of safety, but unbranded chargers do not. Therefore do not buy cheap substitutes.

The photograph (Figure 1) shows an example of a branded charger, which we have no reason to believe is unsafe, with the range of markings to look out for. If a product has all of these, and we can generalise by extending this caution from chargers to consumer and laboratory equipment, then that is a good sign; if any of them was to be missing, then that tells you the product does not comply with standards.

The presence of markings does not guarantee probity – the markings might after all be faked – but the absence of markings is a sure sign that it is not up to standard.



Figure 1 - Markings on a branded power supply. The GS Mark shows that the product has been independently tested for conformance with safety standards.

Workplace first-aid changes

Why? After looking at first aid in the workplace the Health and Safety Executive (HSE) found that 'although first-aid awareness and penetration in workplaces was good, compliance was found to be more "in spirit" rather than the letter of the regulations and this exposed some important deficiencies in the format and content of guidance and in the proportionality of the current regulatory requirements for lower risk employees'.

- What?**
1. The current initial 4-day First Aid at Work (FAW) course will be shortened to three days.
 2. There will be a new qualification of Emergency First Aider in the Workplace (EFAW) that will require a one-day training course.
 3. At the end of the 3-year certification period, first aiders need to undertake an FAW requalification course, or EFAW course.
 4. The FAW requalification remains unchanged at two days.
 5. It is strongly recommended that FAW and EFAW first aiders attend an annual 3-hour refresher course to stop their skills fading.

When? The changes came into effect on 1 October 2009.

And so? Because of the changes employers should consider what's best for their circumstances in light of the hazards and risks in schools. These changes give the employer scope to train more staff in first aid if a school's history of accidents warrants it, albeit to the EFAW level only. They also should allow more to volunteer to become first aiders because the training to EFAW level is less onerous.

Further information

Information on first-aid training and qualifications can be downloaded from:
www.hse.gov.uk/pubns/web41.pdf

'First aid at work' - <http://www.hse.gov.uk/pubns/indg214.pdf> - answers some basic questions about first-aid provision at work.



CORGI bye-bye



On 1 April 2009, the Gas Safe Register took over the statutory gas registration scheme in Great Britain from CORGI. Both schemes protect the public against cowboy operators, but whereas CORGI represented the gas industry, and was mandated to protect the public by the HSE under gas safety legislation, the new scheme is run by an independent contractor working to a 10-year contract under the HSE.

What the public should get from this is greater assurance about the competence of registered gas engineers and the safety of gas supplies. This comes from inspections of work aimed at finding and reducing unsafe practices.

More details about the Gas Safe Register are to be found at this site: <http://www.hse.gov.uk/gas/domestic/further-details.htm>

Drinking water in labs

We have had some queries recently regarding whether teachers should allow students to drink water during science lessons.

This could have something to do with the media message that drinking water keeps us healthy [1]. Up to 60% of the human body is water and the brain is composed of about 70% water, (not to mention the lungs are nearly 90% water and about 83% of our blood is water). Industry groups such as the Natural Hydration Council [2] and suppliers of bottled water are constantly saying that your brain must be regularly replenished by copious amounts of it in order for it to function properly. As a result, students are being encouraged to drink water in classrooms and in some cases school laboratories.

SSERC appreciates the need for students to keep their bodies

hydrated. However, there are significant risks in allowing the practice of drinking in school laboratories. We recommend that the practice should not be allowed for the following reasons:

- a school science laboratory cannot be directly compared to a standard classroom. In science laboratories, hazardous materials are routinely used.
- accidental contamination can, and does, occur even when there is no practical work going on (can you always be sure that the previous class, who may have been involved in practical work, has cleaned the benches thoroughly?).

Although there is no direct legislation aimed at preventing students from drinking in school laboratories, it is accepted good practice **not to allow**

anyone to eat or drink in a laboratory. This 'ban' on drinking in laboratories is also recommended by the Association for Science Education (ASE) and our sister organisation in England, CLEAPSS. If the decision was made to allow students to drink in laboratories and an incident occurred, it could prove very difficult to defend adopting a position which was contrary to accepted good practice.

If students are being allowed to carry water bottles in their school bags etc., we suggest that they be encouraged to have a drink before they enter the laboratory (or wait until they leave the laboratory). In cases where the students cannot wait for the lesson to end in order to have a drink, they should be allowed to wash their hands and leave the laboratory to have a drink.

References

- [1] <http://www.yououghttodrinkmorewater.com/Why-Naturally-Sourced-Water/index.html>
 [2] Natural Hydration Council - <http://www.naturalhydrationcouncil.org.uk/>

New AV installation specification

The document title is PAS 122:2009 'Specification for the installation of audiovisual equipment in classrooms and general publicly accessible areas'. This Publicly Available Specification

(PAS) was sponsored by Becta and its development was carried out by the British Standards Institution (BSI). The standard costs £85 and is available from BSI.

PAS 122 is primarily a specification for employers and installers. Although most of it relates to whiteboards and projectors, its scope is intended to cover many other types of audio visual equipment.

<http://www.bsigroup.com/Shop/PublicationDetail/?pid=00000000030154893>



The SSERC Conference and AGM was held in the Carnegie Conference Centre in Dunfermline at the end of November. In a successful and enjoyable programme the conference keynote address on the subject of “The Role of Web-based Resources in Science & Technology Education” was delivered by Ollie Bray [1], National Adviser for Emerging Technologies in Learning at LT Scotland [2]. In a witty and informative session Ollie encouraged the teaching profession to embrace the technology which younger people already use in a social way. To read more about what he said, have a look at Ollie’s Blog post [3] or Twitter [4] him with your comments.

The official launch of the Science3-18.org website gave an opportunity to hear Ian Birrell, Network Designer at SSERC, update delegates on the progress made on development of the Science3-18.org over the past year. Ben St. Johnston and his team at Learning Curve Software in Edinburgh set up the initial structures and transferred all the materials from the old ISE 5-14 website. The new site is what is called a content-managed website meaning that we can offer ‘google-esque’ search facilities for users looking for resources etc.

Much of the development process has also taken place with help and feedback from a limited number of users who were given access to the new site when they requested to be registered with the

old site. Since January 2009 word had got around and the site managed to clock up 150,000 pages viewed by some 25,000 visitors from 151 countries.

The Home Page is split into three main areas, namely *Curriculum Resources*, *Continuing Professional Development* and a link to the *SSERC SafetyNet* website [5]. The first of these has a menu structure which contains the Experiences and Outcomes for all science & technology-related CfE subject areas plus content statements and suggested practical activities for all SCQF learning outcomes up to Level 7. Therefore, they are available in one, easily searchable place.

An increasingly large number of exemplar articles continue to be added across all subject areas. To date, including curricular data, over 4000 articles have been added. Many of these will have been aired as practical activities, teaching methodologies and technician notes in some of the acclaimed SSERC-run CPD courses. Earlier this year we gathered a group of Primary teachers together and, with support and resources, asked them to come up with real, practical activities in support of the Experiences & Outcomes in CfE. You will need to log-on as a registered user to view these examples of ‘Electricity Enterprise’ and ‘Ice Activities’.

The second main area of the site is *Continuing Professional Development*. This contains information about *CPD Courses*

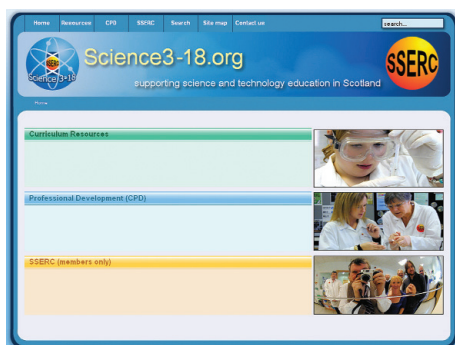
at SSERC, *Learning & Teaching Methods*, *logging-in*, *News*, links to *Other Organisations* and *Contact SSERC*. You can fill in an online form to apply for any of the **residential or non-residential courses**. This information is then passed directly and electronically to the admin system which has been set up in SSERC.

The third area links to SSERC SafetyNet site [5]. In 2010 this will be replaced by a new SSERC site with a design similar to the new Science3-18.org site.

To make sure you get the most out of the website you need to log-on as a registered user as many of the new resource articles have been designated as **registered** – this means that they will only be visible to registered users or those with a **Glow username & password** who have logged on via the link provided on the site.

For more information or a personalised log-on please send your name, school and interest in Science3-18.org to: ian.birrell@sserc.org.uk or check out the site at www.science3-18.org

The continued support of the Scottish Government through cooperation with Learning & Teaching Scotland means that we can strive towards making the Science3-18.org site universally useful to all. The basic structure is now in place to increasingly serve existing needs as well as allowing us to react to the anticipated curricular changes.



Home page



Continuing Professional Development page

References

- [1] <http://www.olliebray.com/>
- [2] <http://www.ltscotland.org.uk/index.asp>
- [3] <http://olliebray.typepad.com/olliebraycom/2009/11/curriculum-for-excellence-science-change-and-new-technologies-sserc-conference-2009.html>
- [4] <http://twitter.com/olliebray>
- [5] http://www.sserc.org.uk/members/SafetyNet/Safety_MENU.HTM
- [6] <http://tiny.cc/ohtfk>
- [7] <http://tiny.cc/ICE754>

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