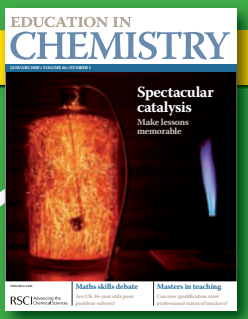
STUDENT SUPPLEMENT

InfoChem



ISSUE 114 JANUARY 2009

WALK ON WASTE

With landfill sites filling fast, the recycling of household waste is becoming increasingly important. So it's good news that researchers at the BAM Federal Institute for Materials Research and Testing in Berlin have come up with a way of taking your rubbish – plastics, empty cans and packaging materials – and reusing it in the production of concrete for making pavements, roads and buildings.

Concrete is made by mixing cement, water and aggregate. The cement is the material that reacts with water to give an adhesive mixture, and is commonly Portland cement, which comprises a complex mixture of calcium silicates with small amounts of other materials. It is made by roasting clay with limestone ($CaCO_3$); small amounts of calcium sulfate are added to vary the setting time. The aggregate is usually one of two types – fine, *eg* sand or gravel; or coarse, *eg* crushed rocks or stone.

Much of our household waste is incinerated, the main product of which is the non-combustible material – 'bottom ash' – that is left behind in the furnace. This bottom ash has been used as a coarse aggregate in concrete production, but its use is limited. Impurities in the ash, such as chlorides, sulfides and very small particles make recycling difficult, and small fragments of aluminium and glass cause cracks in the final product.

Today's waste, tomorrow's walkways

JUPITERIMAGES

In an article published in *Quarterly Journal of Engineering Geology*, the researchers led by Dr Katrin Rübner explain that in the alkaline environment of freshly made concrete aluminium forms $Al(OH)_3$, which can react with calcium ions in alkaline conditions to form $Ca_3[Al(OH)_6]_2$ as a precipitate, and the resulting overall increase in volume causes cracks in the concrete. A high glass content of about 15 per cent can also lead to damage because glass forms alkali–silicates, which also cause expansion and cracks in the concrete.

To clean up the ash, the researchers tried various additional treatments. They reduced the glass content to half by identifying transparent particles of glass optically and then removing them mechanically. They reduced the aluminium content to less than 0.4 per cent by storage in sodium hydroxide and subsequent washing.

The treatments produced higher quality concrete that was free from defects and had better properties such as workability, strength, elasticity and porosity, making it potentially more useful as a building material.

A call for science communicators

You could win £100 for yourself and £500 for your school or college by taking part in the Royal Society of Chemistry Bill Bryson Prize for science communication. This year the competition returns to its original open-theme format so you can write about any aspect of science that interests you. All formats will be accepted – articles, posters, PowerPoint presentations, or work from an after school science club.

The competition is open to all UK school and college students (aged 5–18), and will be judged in two categories – primary and secondary. The closing date is 22 May. For more details and to download an entry form go to: www.rsc.org/billbrysonprize.

IN THIS ISSUE

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ANTIMALARIAL

ISSUE 114 JANUARY 2009

Approximately one million people die annually from malaria worldwide. Tragically, 90 per cent of these deaths are among the under-fives in sub-Saharan Africa, who have little if any access to adequate healthcare. Drugs are used to treat the disease but parasitic resistance to these drugs is growing, so what is the alternative?

Malaria is caused by the parasite – *Plasmodium falciparum* – which enters the human blood-stream when a female mosquito bites its victim, causing fever, nausea and anaemia, and in severe cases, death.

From destruction to treatment

Once inside the blood, the *Plasmodium* parasite quickly makes its way to the liver, where it infects a few hundred cells and multiplies. After several days in the liver, the parasite bursts out of the cells and floods the host's bloodstream, where it infects healthy red blood cells. Inside these blood cells, the parasite digests haemoglobin, the protein responsible for transporting oxygen around the body, obtaining valuable amino acids for its survival and reproduction. As a byproduct of digestion, a toxic haem group is also produced, but this is safely stored as a solid crystal that is non-toxic to the *Plasmodium* parasite.

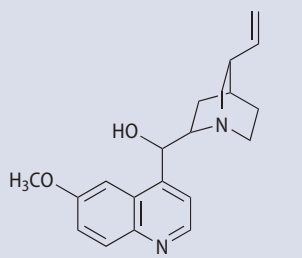
Once the parasite has exhausted its supply of nutrients in the blood cell, it bursts out again ready to infect new cells containing fresh supplies of haemoglobin. This cycle continues until the infection is either treated with drugs or the body's own immune system destroys the parasite.

Death from malaria occurs as a result of blood clotting in the smaller blood vessels of vital organs such as the brain and liver, or from severe anaemia after the parasite has destroyed many of the red blood cells.

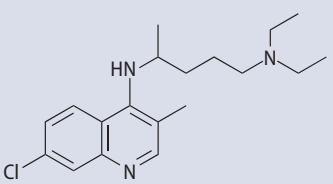
The most common antimalarial drugs are the

The malaria carrier...

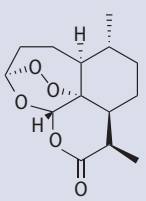
JAMES GATHANY/CDC PUBLIC HEALTH IMAGE LIBRARY



(*1*) Quinine



(*2*) Chloroquine



(*3*) Artemisinin

DRUGS

Plasmodium falciparum

aminoquinolines – drugs that have two fused aromatic rings containing one nitrogen atom. Quinine (*1*) and chloroquine (*2*), for example, have been used extensively over the past century to treat malaria. These drugs prevent the parasite from safely storing the toxic haem group in the infected blood cell, causing it to build up and poison the parasite. Unfortunately, overuse of these drugs has led to the evolution of drug resistance, making them less effective in the treatment of malaria.

To combat this resistance, scientists turned to artemisinin (*3*), a drug used for centuries in traditional Chinese medicine to treat fevers and shown to be effective against drug-resistant *P. falciparum*. Like the aminoquinoline drugs, artemisinin targets the parasite in the blood, but in this case, a peroxide bond, central to the drug's structure, is reduced inside the cell forming two highly reactive oxygen radicals that ultimately kill the parasite.

Peter Winstanley of the school of clinical sciences at Liverpool University, however, told *InfoChem* that 'although drug therapy may be an effective and relatively cheap method of treating malaria, there are hidden costs that come from looking after the desperately sick person. Expert nursing, blood transfusions and laboratory services are all necessary to treat malaria victims and are costly to set up and maintain, and are often beyond the means of those countries worst affected by the disease.'

So is there an alternative treatment that could offer protection against malaria, without the need for costly healthcare? One solution would be to develop a vaccine – ideally, a one-off treatment to give immunity against the *P. falciparum* parasite for the life of the patient.

Towards a malaria vaccine

The principle behind a malaria vaccine is to promote an immune response in the patient against the parasite. This is done by injecting the patient with a safe form of the disease, for example, the dead parasite or a viral 'carrier' whose DNA (genes) has been modified to produce parasitic proteins in the patient's own cells. The doses used are harmless yet they

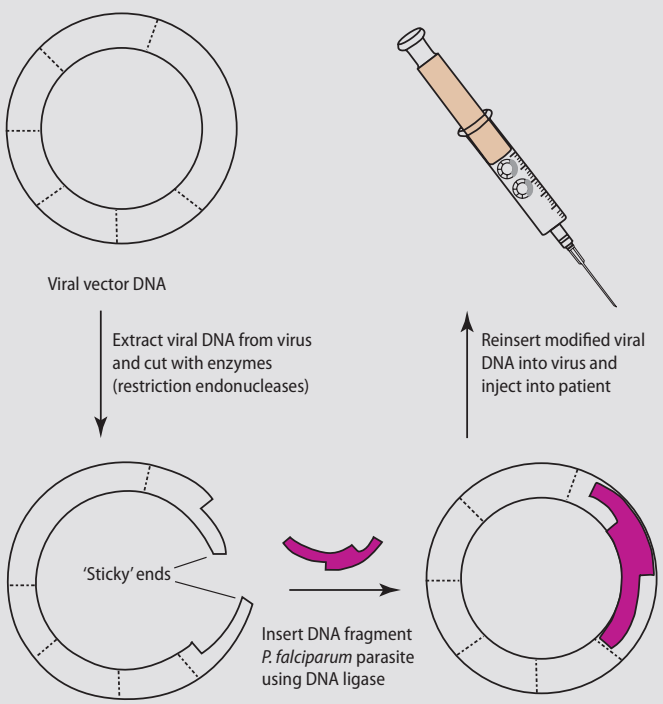
Making a malaria vaccine from a virus

First researchers slice open the circular strand of viral DNA (plasmid) by using enzymes – restriction endonucleases. This creates two 'sticky' ends of DNA where one single strand of DNA overhangs the other, onto which non-viral DNA can be inserted.

In a separate experiment, they isolate and make many copies of the parasitic DNA fragments (genes) responsible for making key proteins of the *P. falciparum* parasite.

They then join the fragments of viral and parasite DNA together by using another enzyme (DNA ligase) and reform the circular DNA plasmid of the virus. They then insert the modified DNA back into the virus, and inject this modified virus into the patient.

Once inside the patient, the virus will infect the human cells, make the parasitic proteins that are now in its DNA and trigger an immune response.



LONDON SCHOOL OF HYGIENE & TROPICAL MEDICINE/SCIENCE PHOTO LIBRARY

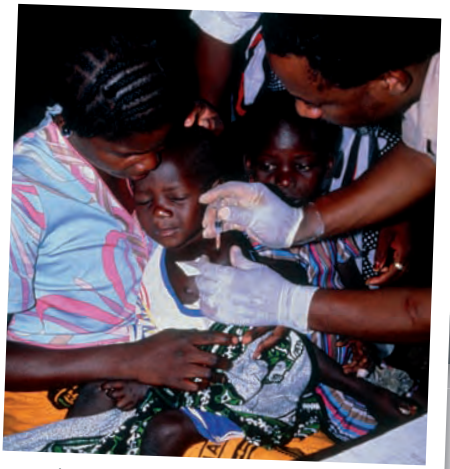
"... THE PARASITE ... IS ABLE TO FOOL THE BODY'S NATURAL IMMUNE SYSTEM."

trigger the body to generate antibodies (proteins) to recognise foreign invaders, bind to them and destroy them. This may sound simple, but in practice, it can be a daunting challenge.

Sarah Gilbert of the Jenner Institute in Oxford is a researcher involved in the development of new malaria vaccines and explained that the *P. falciparum* parasite is a complex single-celled organism that is able to fool the body's natural immune system. 'One of the greatest challenges in developing a malaria vaccine,' she told *InfoChem*, 'is that the parasite is capable of suppressing the natural immune system of the host.' This means that if someone is infected with malaria, then the ability of the body to generate the immunity needed to recognise and destroy the parasite is greatly reduced. This effect is disastrous in developing a vaccine because those most in need, living in high risk malaria areas, are unlikely to be able to generate effective immunity in response to the vaccine.

Gilbert and her colleagues are currently investigating the use of 'viral vectored vaccines'. These are live viruses that have been chemically modified, by inserting or deleting DNA fragments (genes), to make key malaria proteins (see Box). Having been injected, these modified viruses infect the cells and produce foreign parasitic proteins. This triggers an immune response in the patient that promotes the production of antibodies as well as killer cells that can attack the parasite when it is hiding inside the liver or blood cells. Crucially, the DNA fragments responsible for viral replication in these viruses are removed, so there is no chance the virus can multiply and spread.

The Oxford researchers are currently developing two separate vaccines, one to target the parasite in the liver and a second to target the parasite once it has infected the red blood cells. Ultimately, they hope to combine both vaccines so that if any parasites survive the immune response in the liver, a second immune response will kill any remaining parasites once they reach the red blood cells.



... this won't hurt – much!

A MALARIA VACCINE BY 2010?

Currently the most advanced malaria vaccine in clinical trials is RTS,S, developed by chemists at GlaxoSmithKline. Expected on the market by 2010, the vaccine will offer protection against the disease for up to two years. While clinical trials of the vaccine in African children have shown efficacy in only a small number of patients, clinicians hope that if given to younger children who have been less exposed to the disease, the vaccine will provide immunity for a much longer time.

This development, though some way off providing real long-term protection against the disease, represents significant progress towards this goal and offers a lifeline to millions around the world.

Fred Campbell

magnificent molecules:

Fred Campbell, PhD student at Leeds University, highlights his favourite molecules. In this issue: **myosin (II)**

JUPITERIMAGES; ANDY CRUMP, TDR, WHO/SCIENCE PHOTO LIBRARY

Without this molecule you wouldn't have been able to get out of bed this morning, let alone pick up this copy of *InfoChem*. Myosin (II) must, therefore, be one of the most magnificent of molecules.

Introducing the caterpillar protein

Myosin (II) is a protein in the body responsible for muscle contractions you take for granted everyday, from kicking a football to brushing your teeth.

The protein is made up of several thousand amino acids, linked together by peptide (CO–NH) bonds, with a head and long tail that looks similar to a tadpole.

Two of these amino acids intertwine to make the working protein, myosin (II), that sits with its two heads buried in muscle fibres of the muscle.

Myosin (II) fires into action when the brain sends a signal to a particular muscle that tells it to contract. Once this signal has been received, thousands of myosin proteins crawl along the muscle, similar to a caterpillar, pulling the fibres taut and causing the muscle to contract.

The whole process is over in a fraction of a second and the muscle relaxes, ready for the next order to contract. ■

ON-SCREEN CHEMISTRY

Jonathan Hare asks…

GLOBAL WARMING: *can you demonstrate the greenhouse effect?*

In BBC1 documentary *The climate wars*[1] broadcast last September, the presenter, Iain Stewart, demonstrated that CO_2 absorbs infrared (ir) energy and so showed how it can trap heat in the Earth's atmosphere and contribute to the 'greenhouse effect'.[2]

The apparatus

The apparatus comprised a 1 m long, 20 cm diameter tube filled with CO_2 from a cylinder. A lighted candle was held at one end of the tube while a thermal imaging infrared camera viewed it from the other end. The bright false-colour image of the hot candle on the camera screen slowly disappears as CO_2 was introduced into the tube, showing that the gas absorbs in the infrared.

Since I built the apparatus for the programme let me share with you what I learnt about this experiment.

Experimental detail

Owing to its molecular rotations and vibrations, CO_2 has several absorption bands in the infrared, the main ones being at 4.3 μm (2350 cm^{-1}), 7.5 μm (1388 cm^{-1}) and 15 μm (667 cm^{-1}). The latter band lies very close to the maximum of the Earth's ir black body emission, making CO_2 a very important greenhouse gas.[3]

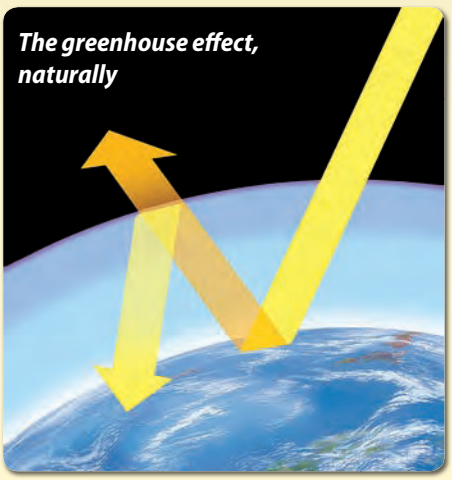
The thermal imaging camera we used was sensitive from *ca* 1 to 5 μm, quite a large part of the infrared spectrum. A lit candle or match produces lots of energy through the infrared to the visible. Consequently, a candle looks very bright (colourful) on the false-colour infrared camera image.

To be able to seal and look through the tube, I covered the ends in cling film. Plastics absorb strongly in the infrared region so it's hardly as transparent as it looks to the eye but the film was so thin these simple 'windows' actually worked quite well in practice. The CO_2 is flowed into one end of the tube and vented out the other so that the tube is well flushed with gas at about atmospheric pressure. In the process the thin film windows bulge a little.

A disappearing act

You might think that when you view the candle through the tube using the camera, and you introduce CO_2, the bright flame would 'disappear', owing to the infrared absorption. However, the flame doesn't disappear. This is because the CO_2 absorptions observable by the infrared camera are weak and are only in a relatively small part of the spectrum.

… now that's what I call cool



The greenhouse effect, naturally

The only way to get the demonstration to work is to have a 'CO_2 filter' on the camera, which only lets through infrared at around 4 μm, close to one of the CO_2 absorptions (which are broadened a bit at atmospheric pressure). The filter blocks out much of the infrared energy so that the CO_2 absorption is not so swamped and this allows us to observe the 'vanishing candle'.

In another programme on climate change[4] recently broadcast in the US, the same experiment was done using a military state-of-the-art infrared camera and CO_2 filter (unfortunately not available for us to use in the UK). It was so sensitive that they used the heat from the presenter's face rather than a candle to demonstrate the effect. ■

REFERENCES

1. *The climate wars*, BBC1 September 2008, see: http://www.bbc.co.uk/programmes/b00dhlgl

2. See, for example, the Wikipedia section on 'greenhouse effect'.

3. *Greenhouse gas absorption spectrum in the Earth's atmosphere*: www.iitap.iastate.edu/gccourse/forcing/spectrum.html

4. *Global warming: what's up with the weather?*, Nova, DVD. ISBN 978 1 59375 729 8

Dr Jonathan Hare, The CSC Centre, Chemistry Department, University of Sussex, Brighton BN1 9ET (www.creative-science.org.uk/TV.html).

BACKYARD CHEMISTRY

DR HAL SOSABOWSKI PRESENTS EXPERIMENTS YOU CAN DO ON YOUR OWN

IN THIS ISSUE: non-Newtonian liquids

THE SCIENCE

Slime, cornflour, quicksand and ketchup are all non-Newtonian liquids. They are also 'thixatropic liquids', from the Greek *thixis*, meaning the act of handling and *trope*, meaning change. So when a force is applied to a non-Newtonian liquid, it can now act like a solid.

EXPERIMENT 1

A cornflour/water mixture acts counter intuitively. The harder it is pushed, the harder it feels, and the converse is also true, the softer it is pushed the softer it feels.

MATERIALS

You will need:

- half a cup of cornflour;
- mixing bowl;
- cup of water;
- tablespoon.

HEALTH & SAFETY

There are no particular health and safety issues with this demonstration.

METHOD

Put half a cup of cornflour into a bowl and add a cup of water, a little at a time, until you get a consistency like melted ice cream. The starch molecules making up the cornflour are now suspended in water. Notice that it is fairly easy to stir slowly but incredibly difficult to stir fast. Now punch the mixture or smack the surface with a tablespoon. You will find it hard and it may even crack. If, on the other hand, you press it slowly, your finger will slide through it as if it is a liquid. This is because cornflour is a non-Newtonian liquid, *ie* when it is pressed slowly the molecules flow over each other like a liquid, but when pressed hard they are squashed closer together and become solid.

EXPERIMENT 2

In this experiment you are going to make synthetic slime using borax (sodium tetraborate decahydrate) and PVA (polyvinylacetate) glue. PVA molecules are long and can slide over each other easily. This causes PVA to be viscous. When you add borax to the glue, this joins up (or crosslinks) the PVA molecules. The resulting network of molecules stops water molecules flowing away so easily, and the liquid gains some solid-like attributes of slime.

MATERIALS

You will need:

- 300 ml of water;
- 100 ml of PVA glue;
- measuring cylinder;
- two spatulas of borax (available from chemists or on e-bay, £2.99 for 300 g);
- three discardable glasses (two should be about 300 ml each, one should be a pint glass or similar);
- discardable teaspoon;
- food colouring.

HEALTH & SAFETY

Borax can be harmful if swallowed and is an irritant. Wash your hands after touching the slime – do not taste or ingest slime. Wear eye protection and apron/laboratory coat for this preparation. Slime can be removed from clothing with warm soapy water.

METHOD

Pour 100 ml of water and 100 ml of PVA glue into a glass. Mix well. Add food colouring if you want to colour your slime. Pour 200 ml water into the second glass and dissolve the borax into it. Pour the PVA glue solution into the pint glass. Slowly add the borax solution to the glue, stirring continuously. The mixture will begin to separate out into a liquid part and a slimy part. Scoop out the slimy part and start to knead it, this is your slime. The watery phase can be discarded in the sink. The slime can be stored in a plastic bag.

TRAINEE PATENT ATTORNEY:
David Carling

David has spent the past six months working as a trainee patent attorney for Potter Clarkson LLP. He talks to Rachel Bolton-King about his typical day.

David Carling

Potter Clarkson LLP is an independent, UK and European patent and trademark law firm based in Nottingham. David is training in patent law within the chemistry and pharmaceuticals department and it will take him five years to qualify. Patents are granted to protect the intellectual property of clients to ensure their competitors cannot make the same products or use the same processes.

The patent process

David's training is mostly on the job, with annual exams leading to qualification. In his day-to-day work he deals with real patents and his work is scrutinised by his supervisor, who is a qualified patent attorney. During his training, David's tasks will cover all aspects of getting a patent to grant (prosecution) and enforcing clients' patent-protected rights. Currently, David is learning how to draft patents for chemical products, file patent applications and obtain and defend a patent in countries his client seeks patent protection.

Clients approach the firm with products to be patented, *eg* a family of 30 related anticancer compounds. David creates one patent application to cover all 30 chemicals, and any future compounds suggested by the client. Initially, he determines the compounds' common core chemical structure and details the location of all possible functional groups attached to this core. The client then provides David with the reaction methods used to make the compounds. Using his chemical knowledge, David must outline all possible reactions that could be used to make these chemicals. This is to broaden the patent protection and prevent the client's competitors using the same general procedure but with slightly different reaction conditions.

David may spend many hours drafting a patent, he has to ensure the wording is concise and unambiguous. The client provides information on the product's applications and David also includes in the patent specification test data from the client, *eg* nmr data, to prove that the compounds made are those described in the patent, and biological test data to confirm their anticancer properties.

When complete, David files the patent application with the World Intellectual Property Organisation (WIPO), which briefly examines its patentability – *ie* that the product is novel, inventive and industrially useful. Finally, the patent is sent to patent offices in each of the client's nominated countries to be independently examined and granted. The inventive step requirement is often the most difficult for David to defend. By consulting patent case law and scientific literature, he must prove that a scientist would not have normally thought of the proposed substance or the method for formulating it. David can spend more than five hours researching and composing a carefully worded letter to defend an issue with a patent application. Examination can require many man-hours and it sometimes takes 10 or more years for a patent to be granted.

Innovative science

David enjoys the challenge of working on patents for a wide array of chemical products, which keeps him informed of innovations in science. After qualifying, David will be responsible for protecting the futures of chemical companies, with £millions at stake every time. ■

Pathway to success

- 2008–present, trainee patent attorney, Potter Clarkson LLP, Nottingham
- 2006–08, regulatory affairs officer, a contract research organisation, Derby
- 2002–06, PhD in bioinorganic chemistry, Nottingham University
- 1998–2002, MSci chemistry (1st), Nottingham University
- 1996–98, chemistry, physics, maths and further maths A-levels, Beechen Cliff School, Bath

***PhD student, Rachel Bolton-King was given a grant by* Chemistry: the next generation (C:TNG) *to write this article in collaboration with* Education in Chemistry.**

£50 OF HMV TOKENS TO BE WON!

Benchtalk

ISSUE 114 JANUARY 2009

PRIZE WORDSEARCH No. 43

Students are invited to find the 34 words/expressions associated with Nature and its products hidden in this grid. Words read in any direction, but are always in a straight line. Some letters may be used more than once. When all the words are found, the unused letters, read in order, will spell a further eight-letter word. Please send your answers to the Editor at the usual address to arrive no later than Monday 9 February. First correct answer out of the editor's hat will receive a £20 HMV token.

R	S	B	T	A	X	U	S	B	A	C	C	A	T	A	D	C
E	N	E	I	R	N	L	W	M	I	M	D	O	A	L	I	N
T	I	E	C	C	I	I	E	M	R	O	R	Q	X	T	O	O
E	E	R	I	O	L	O	Y	E	E	R	U	U	O	E	L	I
M	T	G	T	M	L	R	C	D	N	P	G	I	L	P	A	T
O	O	N	O	P	I	O	I	I	O	H	B	N	C	E	K	U
R	R	I	I	A	C	T	F	C	R	I	T	I	E	N	L	T
T	P	D	B	C	Y	S	I	I	T	N	R	N	R	I	A	I
C	E	O	I	T	X	A	C	N	S	E	E	E	E	C	S	T
E	N	C	T	I	O	C	A	E	E	U	E	L	T	I	Y	S
P	Z	E	N	N	M	L	P	L	A	N	E	T	O	L	N	B
S	Y	N	A	M	A	S	P	O	N	G	E	S	X	L	T	U
S	M	E	U	R	O	P	E	A	N	Y	E	W	A	I	H	S
S	E	G	U	H	Y	O	S	C	I	N	E	E	T	N	E	E
A	S	T	S	I	S	E	H	T	N	Y	S	O	I	B	S	N
M	A	N	A	T	U	R	A	L	M	O	U	L	D	S	I	E
N	E	N	C	O	D	E	D	E	N	Z	Y	M	E	S	S	G

AIR
ALKALOID
AMOXYCILLIN
ANTIBIOTIC
BEER
BIOSYNTHESIS
CASTOR OIL
COMPACTIN
DRUG
ENCODED ENZYMES
ENZYMES
ESTRONE
EUROPEAN YEW
GENE CODING
GENE SUBSTITUTION
HYOSCINE
IR
MASS SPECTROMETER
MEDICINE
MORPHINE
NATURAL ANTIBIOTIC
NATURAL MOULDS
NMR
PACIFIC YEW
PENICILLIN
PLANET
PROTEINS
QUININE
SPONGES
SYNTHESIS
TAXOL
TAXOTERE
TAXUS BACCATA
TREE

November PRIZE WORDSEARCH No. 42 winner

The winner was Joshua Duffy of Haydon Bridge High School, Northumberland. The seven-letter word was METHANE.

FIND THE ELEMENT No. 6

Students are invited to solve Benchtalk's *Find the element* puzzle, contributed by Dr Simon Cotton of Uppingham School. Your task is to complete the grid by identifying the 10 elements using the clues below.

ACROSS

1. This metal forms a green carbonate which turns black when heated. The black residue dissolves in dilute H_2SO_4 without effervescence, forming a blue solution.

2. This metal can be displaced by copper from solutions of its salts.

3. Most reactive halogen.

4. Very unreactive non-metal which combines with hydrogen in the presence of a suitable catalyst.

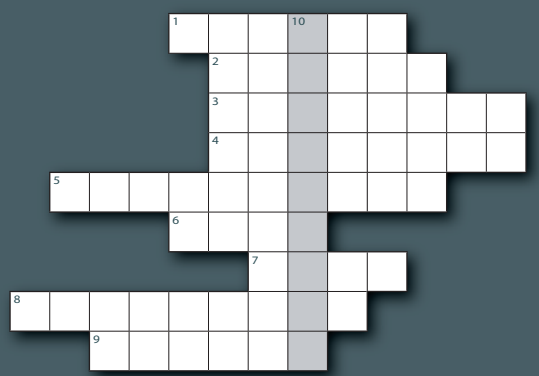
5. Poisonous non-metal which burns with a yellow flame, forming dense white fumes of its oxide X_2O_5. This is sometimes used in smoke bombs.

6. This metal forms a brown oxide, formula M_2O_3.

7. Heating the carbonate of this metal gives an oxide that is yellow when hot but white when cold.

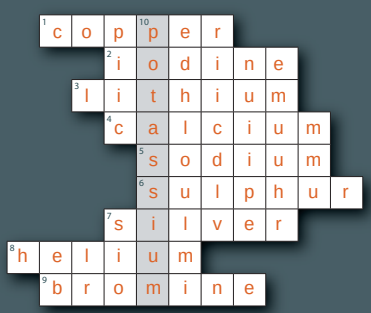
8. This metal which forms a M^+ ion reacts very rapidly with cold water.

9. The Group II metal used in the sulfate test.



If you have found the correct nine elements, in 10 down you will have generated the name of a poisonous radioactive metal.

Please send you answers to: the Editor, *Education in Chemistry*, the Royal Society of Chemistry, Burlington House, Piccadilly, London W1J 0BA, to arrive no later than Monday 9 February. First out of the editor's hat to have correctly completed the grid will receive a £30 HMV token.



Find the element no. 5 solutions and winner

The winner was Briana Langman from Sir Henry Cooper School in Hull.