The Mole

... FOR ANYONE INSPIRED TO DIG DEEPER INTO CHEMISTRY

ISSUE 1 | JANUARY 2012

Can solar power change the world?

Nina Chadwick and Neil Robertson find out how materials developed by chemists can provide power for all

SHUTTERSTOCK

Scientists must continue to develop solar cells which are cost effective and practical

Imagine a world without the sun. It is colder than humanly imaginable. Water doesn't exist, all we have is ice. There is never any daylight and plants can't photosynthesise, so they can't survive. Solar power has changed the world. Since the beginning of mankind, the sun has provided our most innate human requirements – warmth, light and food. Since the late eighteenth century, the sun has provided us with much more.

A simple life

The mid 1700s saw the beginning of the industrial revolution. Before then, the majority of mankind lived a relatively simple life. However, mostly due to the development of the steam engine by James Watt in 1775, we began to work much faster and more efficiently. The subsequent economic growth was unprecedented, and since that time huge advances in technology have allowed us to use electricity as

In this issue

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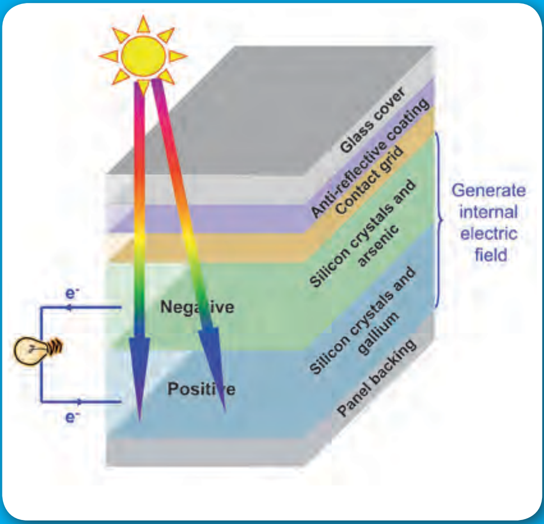
Silicon solar cells use a small, controlled amount of impurities to allow an electical field to be created



we wish and improve communications dramatically. Compared to times before the industrial revolution, we all live the life of royalty – the amount of energy we consume is the equivalent of having 125 human slaves working for each of us 24 hours a day, 7 days a week.

This increase in wealth and lifestyle is built on fossil fuels. Fossil fuels were formed from plants and animals which, ultimately, stored energy from the sun over hundreds of millions of years. The problem is that we are using this energy quickly. The rate at which we are currently using fossil fuels compared to the length of time they took to form, is the equivalent of someone spending their entire annual income in 30 seconds. The position of a person with no income for the rest of the year is the position we are currently creating for future generations. We are in the midst of 30 seconds of extravagance. What happens afterwards?

Energy from the sun

Thankfully, we still have the sun. Instead of continuing to use the minute stores of energy generated in plants millions of years ago, we now have the technology to use the sun's energy every day. The amount of energy reaching the Earth's surface every hour would meet the world's current energy demands for an entire year. So, we can continue to live like royalty, but we no longer need to gamble the lifestyles of future generations.

Take a moment to think about those people who don't live our life of luxury. There are 1.6 billion (more than 1 in 5) people in the world who have no access to reliable electricity. Instead, kerosene (which is bad for the health and expensive) is used to power unreliable generators to produce electricity. Solar power has begun to change all of this. Companies like Solar Aid are working with rural communities to install solar cells which provide electricity for power during the day and charge batteries to provide electricity through the night. This power can be used for medical treatment, education, or work to provide an income for a family. In this way, solar technologies could help address the unbalance in the lifestyles of the developed and developing world.

Converting sunlight to energy

So how is it that we convert sunlight into useful energy? Firstly, the sun can be used for heating water which can be used for central heating systems. On a larger scale, this heat can be concentrated using mirrors so that solar power replaces coal in heating water for power plants. Secondly, some chemists and biologists are also working together to find ways to mimic photosynthesis in plants and use the sun's energy to produce different types of fuel. Finally, the sun's energy can also be directly converted into electricity using a solar cell.

Evolution of solar cells

The first solar cell was built by Charles Fritt in 1883. Since then, although the improvements in technology have been huge, their use has been limited.

In contrast, consider the mobile phone. The first mobile phone call was made in 1946 and the first hand held mobile phone was developed in 1973. Since then there has been an astonishing increase in the number of people using mobile phones. Due to this commercial success, the technology is still developing at an incredible rate. A similar phenomenon is beginning with solar cells.

Over the last five years, more and more people have installed solar cells on their roofs. The technology behind these solar cells is now incredibly advanced. Due to the increase in demand for solar cells, the technology is becoming cheaper and better. It is predicted that during the six years it would take to build a coal fired power station, it will become cheaper to obtain electricity from solar cells than from this power station.

But how effective are solar cells in the UK? It's often cloudy, it regularly rains and it's not often sunny. Think back to when you were last in a field in the UK. Was the grass green? Were there any trees or flowers? Enough sunlight reaches the UK for plants to thrive, despite our weather, and therefore enough sunlight reaches the UK for us to use solar cells.

There are many different types of solar cells but the most familiar, the type you see on rooftops, are silicon solar cells. These solar cells use the element silicon with a small amount of finely controlled impurities in it which allow an electric field to be created.

When the silicon absorbs a particle of sunlight (a photon) an electron is excited. This means that it is promoted to a higher energy level, and the energy of the photon has been transferred to the electron.

Find out more

www.thesolarspark.co.uk

www.solar-aid.org

The science behind dye-sensitised solar cells **http://slidesha.re/dyesolarcell**

www.g24i.com

G24 INNOVATIONS

Due to the internal electric field, the electron diffuses to one side of the cell. The other side of the cell therefore becomes positive and the electron moves around the circuit back to where it began. As lots of photons hit the cell, lots of electrons flow around the circuit and electricity is generated.

Portable solar cells

Although silicon solar cells have many advantages, they are brittle and comparatively heavy. Imagine that you are walking along a busy street. You take out your mobile phone to make a call to find the battery is dead. How convenient would it be to have a solar cell incorporated into your jacket or your rucksack so that you could charge your phone on the spot? This wouldn't be practical with silicon solar cells. However, researchers from nine UK universities involved in The Solar Spark project are helping to develop newer technologies which make this seemingly futuristic idea a very real possibility – in fact, it is now possible to purchase a rucksack with an incorporated solar cell.

Dye-sensitised and organic solar cells

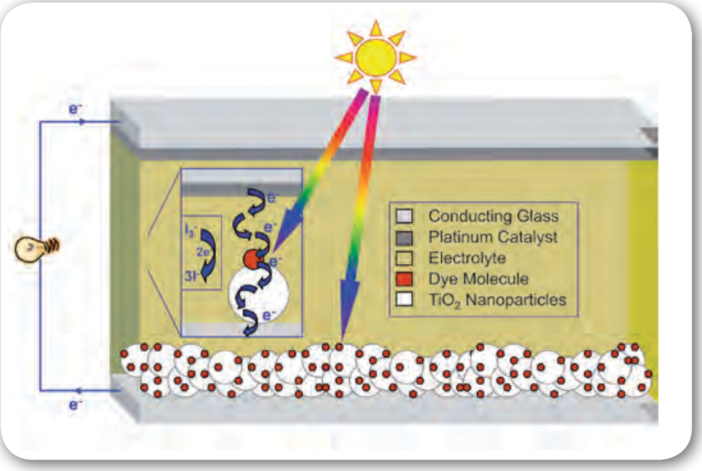
These new types of technologies are called dye-sensitised and organic solar cells. They work in a very different way to silicon solar cells. Unlike silicon solar cells, which require an incredibly high purity of silicon to work, they use materials which are cheap, readily available and non-toxic. You can make a solar cell using titanium dioxide (also found in paint, sun tan lotion and toothpaste), fruit dyes to absorb the sunlight and a liquid electrolyte made up of iodine and iodide anions which completes the electrical circuit. Try it for yourself.

Both organic and dye-sensitised solar cells can be literally printed onto a special type of plastic. As well as using cheap materials, they are very easy and cheap to manufacture. As they are printed onto plastic, they are flexible and more robust than silicon solar cells. Again, think about those who are less fortunate. Since these solar cells are cheap, portable and robust, the technology is much more accessible for the developing world than silicon solar cells.

The future

Due to the nature of the technology, the role of chemists is irreplaceable. Chemists must design new dyes, and develop materials for better transport of electrons. They must also 'characterise' each new material to ensure that the energy of the electron 'fits in' with the other materials – the rest of the solar cell. This is important as, like a car engine, if one part doesn't fit, the whole thing doesn't work. In this way, chemists, along with physicists and engineers must all work together to find the best materials which fit together to make the solar cell work as well as possible.

Can solar power change the world? For some communities in developing countries, it already has. Scientists must continue to work with businesses, economists, architects, designers and a whole host of other professions to make sure that solar cells are practical, cost effective and appealing. Solar cells will continue to make a large contribution to reducing the world's dependency on fossil fuels, closing the poverty gap and changing the world.



Try it yourself

Use the instructions for our *Grätzel cell* experiment and *solar cell in a straw* experiment on the 'teachers' page of our website and within an hour you will have made your own working solar cell!
www.thesolarspark.co.uk

Dye sensitised solar cells are easy and cheap to manufacture

Magnificent molecules

In this issue: ethylene glycol

Ever wondered how de-icer melts the ice on a windscreen? **Phillip Broadwith** takes a look.

A molecule familiar to anyone who has tried to scrape a thickly encrusted layer of ice from the windscreen of a car is ethylene glycol – the principal ingredient of antifreeze and deicing sprays.

Spraying a solution of this simple molecule onto an icy surface can melt away the ice and allow you to get on with your journey. Mixing it with the water in a car's windscreen washing jets stops that from freezing too and you can keep the windscreen as clear.

How does it work?

Ethylene glycol can do this because it is structurally quite similar to water. It comprises two linked carbon atoms, each bearing a hydroxyl – or OH – group. Because of these hydroxyl groups, it can form hydrogen bonds between molecules in the same way that water does. This means that it mixes with water.

The freezing point of pure water is 0°C. The freezing point of pure ethylene gycol is –12°C. But when the two are mixed together, they interfere with each other's attempts to organise into ordered solid structures. In fact this is quite a general phenomenon – dissolving a solute will usually lower the freezing point of the solvent and this is exactly the same way that spreading salt on the surface of roads stops them from icing over.

So why don't we just use salt to deice our cars? Well, salt can only lower the freezing point of water to about –10°C, which might not be enough in the depths of winter to actually thaw the ice out. On the other hand, 70% ethylene glycol in water won't freeze until about –50°C. Salt is also rather corrosive to metal car parts, which ethylene glycol is not.

Some issues

However, there is a down side to the popularity of ethylene glycol as an antifreeze, and that is its toxicity. Pure ethylene glycol tastes and smells quite sweet, and this means that pets such as cats or dogs quite often lap up spillages and become very ill. For this reason most commercial antifreeze products now contain very bitter additives to deter people and animals form drinking them.

This sweetness is also the root of a common misconception that antifreeze is added to wine by unscrupulous winemakers to make it sweeter. In fact, these villains are more likely to add diethylene glycol which retains the sweetness but is much less toxic.

But antifreeze only accounts for a small percentage of the 20 million or so tonnes of ethylene glycol produced every year. The vast majority of this simple diol is used to make polyester plastics, particularly poly(ethylene terephthalate) or PET – the transparent, shiny and easily processed plastic that makes drinks bottles and fibres for clothing and textiles.

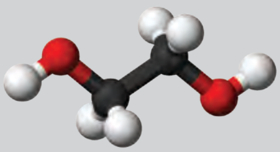
So the next time you wrap up warm in a fleecy jumper made from polyester fibres to spray and scrape the ice from your car windscreen, spare a thought for the little molecule that makes it all possible.

SCIENCE PHOTO LIBRARY

Did you know?

The treatment for ethylene glycol poisoning is relatively simple, but requires urgent medical attention. The enzyme responsible for converting ethylene glycol into toxins is the same one that processes alcohol, but its affinity for alcohol is 100 times higher.

Therefore a large dose of alcohol – usually given



Ethylene glycol (1,2-ethanediol)

by intravenous drip in hospital rather than a good slug of whisky – can saturate the enzyme, preventing it from converting the glycol into more toxic compounds. compounds

Find out more

Check out the podcasts from *Chemistry World*. Each week a leading scientist or author tells the story behind a different compound. www.chemistryworld.org/compounds

Avogadro's Lab

In this issue: The Mpemba Effect

Does hot water freeze more quickly than cold water?
By **Paul Hogg**

Time to perform experiment: **5 mins, then check at regular intervals**

Safety: **Care: hot water**

Introduction

For many, it may seem odd that hot water freezes more quickly than cold. However, throughout history, it has been known that warm water does in fact freeze faster. This phenomenon was brought to public attention in 1963 by a 13 year old Tasmanian student called Erasto Mpemba. He came across this by accident as he rushed to make ice cream and didn't allow time for his milk and sugar mixture to cool (He was trying to make sure that there was enough freezer space left.). To his amazement he found that the ice cream he made by freezing a warm liquid had frozen before his classmates' made with cold mixtures. But here is the amazing bit of the story: when he told his teacher what he had observed, the teacher told him that he must have been mistaken, as a warm liquid could not freeze before a cooler liquid. Nobody believed him.

Fortunately, Mpemba didn't give up and eventually put his observations forward to a university professor who visited his school. The professor tried out his experiment and found that hot water did freeze more quickly than cooler water. Over the years many people have tried to perform this experiment, some have managed to replicate it and some have failed.

This experiment, which at first seems to go against our understanding of how things cool with time, is an excellent example of how scientific research can lead to a magical understanding of chemistry. It also demonstrates that there is no age restriction or hurdle at which someone becomes a scientist, because being a scientist is just a matter of thinking scientifically.

Several theories have been proposed to explain the phenomenon and in this issue we are going to test out some of those ideas. First of all, its important to start by setting up your equipment properly.

The experiment

In this experiment, we will attempt to see what effect that the initial temperature of the water has on how fast it will freeze.

Method

- First, make enough space in a freezer to hold two mugs of water.
- Fill one mug with warm water (from a kettle or the warm water tap) and the other from the cold tap.
- Place both mugs in the freezer and start your timer.
- Check the solutions at regular intervals to see which one freezes first.

Variations

You can vary the experiment by:

1. adding food colouring to check for convection (add a drop but don't stir)
2. place the cups on an eggbox to reduce surface contact with the freezer
3. adding salt or sugar to see what effect solutes have on the rate of freezing.

And finally...

It is important to be open minded with chemistry, and science in general. Some things that first appear to be a contradiction to our understanding can in fact be the opening idea to a new theory or concept (remember how the Mpemba effect was first rejected by his classmates and teachers). By keeping an open mind on what he observed and not on what he expected to see, Mpemba was able to show that hot water did in fact freeze more quickly than cool water.

Mpemba later became a scientist.

THINKSTOCK

Materials and equipment

- **Two mugs (same size)**
- **Cold tap water**
- **Warm water**
- **Thermometer**
- **Timer (watch/stopwatch)**
- **Egg box**
- **Food colouring**
- **Salt or sugar**

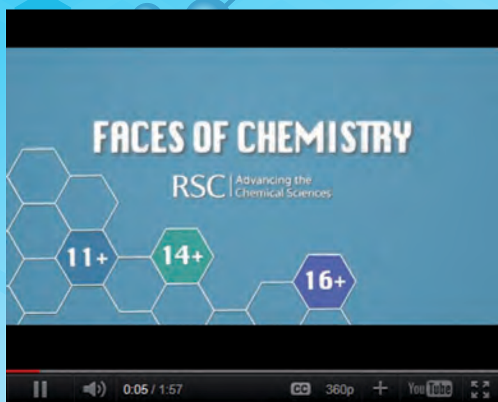
Did you know?

Ice has a regular crystalline structure, which is very similar to that of diamond.

Faces of chemistry

Who do you imagine when you think of the faces of chemistry?

Perhaps Dmitri Mendeleev, Humphry Davy or Marie Curie?



The RSC has launched a project to find and document some of the current faces of chemistry. These are captured in short videos which highlight the diversity of chemistry in our society, and some of the people and organisations represented and the work they do may surprise you. They are produced in collaboration with leading chemical companies and document the views of scientists passionate about the impact they have on the real world.

Faces of Chemistry provides exclusive 'behind the scenes' access to the chemical industry. The videos offer an insight into some real-life applications of chemistry, and in particular the science behind making the products that we use in everyday life. And that's the beauty of chemistry; its uses and applications form the bedrock of many of the things that we take for granted.

The three films feature people working with hair colourants, catalysts and crop protection agents: all things that we take for granted, or may not be even be aware of, but which all rely on chemistry. They also offer an excellent insight into the chemistry they use in their jobs and showcase some of the careers available for chemical scientists.

There are currently three *Faces of Chemistry* videos, but more are being added all the time.

- Scientists from Procter & Gamble explain the chemistry involved in how hair colourants dye your hair
- A scientist at Syngenta shows how crop protection products help to increase yield and produce healthier crops
- You can also find out from scientists at Johnson Matthey how catalytic converters reduce harmful emissions produced by vehicles

http://www.rsc.org/FacesofChemistry

Rio Hutchings

Find out more

If these videos have whet your appetite, then here are some further profiles of people who have built their careers on the chemical sciences

http://www.rsc.org/profiles

http://bit.ly/abpianalytical

http://bit.ly/cogchem

Coming up

You may be interested in the following public lectures at The Chemistry Centre in London:

- 2 February – The future for the global transport sector to 2050
- 1 March – Genetic fingerprinting: past, present and future
- 12 April – The chemistry of art

For more information visit **http://www.rsc.org/publicevents**

Degrees: vocational or subject specific?


THINKSTOCK

With over 50,000 undergraduate courses to apply to through UCAS how do you decide which one is right for you?

One of the first things you need to decide is which subject you want to study. On the face of it an easy decision. But is it really?

Quite often you'll study a subject so that you can get a particular job on graduation – but what sort of job? Do you want a vocation or a career? This is where it gets complicated.

If you study medicine chances are you'll become a doctor, and if you study law, a lawyer. So far so clear, everyone knows what they do as a job. But what happens if once you've qualified as a doctor you realise it's not right for you? Your vocational degree will qualify you to be a doctor or a vet or a dentist, but if you want to change your mind at a later date your options might be limited.

However, if you study chemistry at degree level, once you graduate, your career options aren't reduced. In fact quite the opposite: a huge range of careers open up for you.

The graduate job market is becoming much more competitive as the numbers going to university reached a record high for new admissions in 2010. While numbers were down overall in 2011 the graduate job market has become more fluid with fewer 'jobs for life'. This means graduates have to be able to compete and a chemistry qualification provides you with the skills and the knowledge to do that.

If you're after more information about careers from chemistry, visit the RSC at the Science Careers stand at one of the following UCAS HE fairs:

- Manchester: 5–6 March
- Cardiff: 19 March
- London: 28–20 March
- Tyneside: 25 April

http://bit.ly/ucasconventions

Dates for your diary

ChemNet Events:

ChemNet events are supported by an education grant as part of the Reach and Teach program funded by the **Wolfson Foundation**

▶ Diamond Light Source
18 January 17:00–19:30
Diamond Light Source Ltd, Didcot, Oxfordshire

Take a look around the UK's national synchrotron science facility.

http://bit.ly/DLS180112

▶ Quotient Biosearch
24 February 09:00–14:30
Quotient Biosearch, Fordham, Cambridgeshire

Behind the scenes at Quotient Bioresearch, one of the world's most extensive bioanalytical facilities.

http://bit.ly/quot240212

▶ Look what chemistry has done for me
22 March 19:00–21:00
Royal Society of Chemistry, Cambridge

Find out more about careers in chemistry from a range of people using chemistry everyday.

To book a place on a ChemNet event:
E: events@rsc.org
T: 01223 432340
or book online and find more info about all the events at:
www.rsc.org/chemnet
http://my.rsc.org/chemnet

It's not just athletes who **go for gold**!

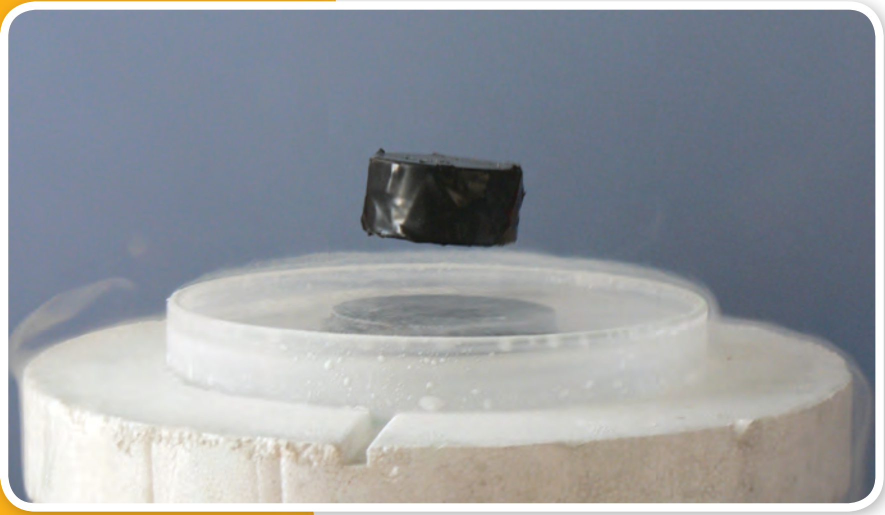
Enter the UK Chemistry Olympiad 2012 to compete for a place in the UK team for the 44th International Chemistry Olympiad in Washington DC. Register by 13 January at **www.rsc.org/olympiad**

Warm-up question

Olympic gold medals haven't been made of gold since 1912, what are they made of now?

Answer: Gold medals are in fact gilded silver rather than real gold. Gold and silver medals are 92.5% silver but gold medals must be plated with at least 6 grams of gold.

100 years of superconductivity



WIKIPEDIA

A magnet levitating above a superconductor cooled by liquid nitrogen, demonstrates the Meissner effect

In 1911, Heike Kamerlingh Onnes, a low-temperature physicist, discovered the extraordinary phenomenon of superconductivity. He found that some metals, when cooled to very low temperatures, have no electrical resistance. So a wire made of these metals can carry an electric current around it forever, without needing a battery or other power source. This discovery came as a consequence of Onnes' research on techniques to liquefy gases with the goal of reaching absolute zero. In 1908 he had managed to make liquid helium, which required temperatures as low as just 4 degrees above absolute zero. When he carefully cooled mercury wires using liquid helium he found that their electrical resistance dropped to zero.

Levitating magnets

The story of superconductivity is one of many breakthroughs of the 20th century and challenges for the 21st century. It took until 1957 until a theoretical understanding of how materials become superconducting at low temperatures was achieved. In 1933 Walther Meissner and Robert Ochsfeld discovered that, in addition to their amazing lack electrical resistance, materials in the superconducting phase repel magnetic fields. This means that if a magnet is placed on top of a superconductor it does not rest touching the surface, but hovers or levitates above it as the magnetic field is forced to pass around the superconductor!

Another set of surprises has been the discovery of new classes of materials (for example some ceramic, organic and iron-based materials) that become superconducting at higher temperatures. The record was set in 1993 by a copper oxide that becomes superconducting at 135 K. An understanding of how certain materials become superconducting at high temperatures has still not been achieved.

Applications

The most widely known application of superconductivity is Magnetic Resonance Imaging (MRI) scanning which is an increasingly routine procedure for medical imaging. The high magnetic fields needed for MRI scanners are made possible by the large currents passing through the superconducting wires in electromagnets.

Very high magnetic fields created by superconducting electromagnets are also used to steer the high energy protons on curved paths around the Large Hadron Collider.

The Meissner effect has also created excitement about the possibility of fast magnetically levitated trains such as the Yamanashi test line in Japan.

Current active research

Research in superconductivity is still extremely active, ranging from experimentally identifying, synthesising and studying new superconducting materials, to the quest to understand how materials become superconducting at higher temperatures. The promise of these new materials is tremendous. For example, for a new generation of MRI scanners which do not require cooling using liquid helium, making them much less expensive. There are also limited global supplies of helium.

Also on the applications side, higher temperature superconductors may play a major role in future generations of electricity grids, reducing the energy lost to heat and enabling large scale distribution of electricity generated from renewable energy sources. Current higher temperature superconducting materials are too fragile to be used on a large scale. There are small demonstrator sections of superconducting grids which are part of large initiatives such as EU MENA (European Union Middle Eastern and North African), a project which aims to include exploring options for transporting solar electricity produced in the Sahara Desert to Europe. *Deirdre Black*

Did you know?

A train reached a top speed of 361 mph on the Yamanashi test line in Japan in 2003, breaking the world speed record for the fastest non-conventional manned rail vehicle.

Cutting-edge chemistry

World's smallest remote control car debuts

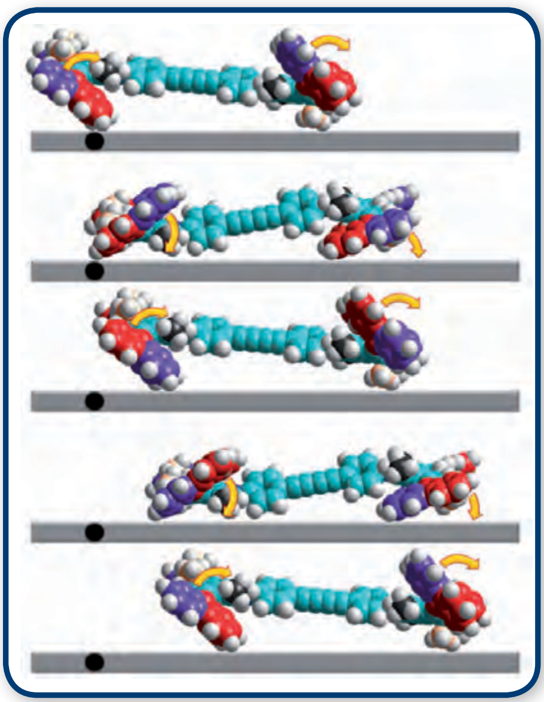
A tiny remote-controlled four-wheel drive electric vehicle has been made by chemists in the Netherlands. The single molecule car's 'wheels' can be made to turn in response to tiny electrical pulses, propelling it across a surface.

Nanoscale machines that can move around, carry loads and construct objects from the bottom up is a long-held goal of nanotechnology, mimicing the action of nature's molecular robots. As Ben Feringa from the University of Groningen, explains, controlling a molecular vehicle is very different to driving a car. 'There is no effect of gravity or weight to keep it on the road – you're working with conformational changes and interactions with the surface,' he says. 'If you're not careful the molecules will just fly around all over.'

Motion control

Several research groups have made nanoscale cars or walkers, but these have either moved by diffusion, been pushed by a microscope tip or had some kind of programmed track to walk along. Feringa's vehicles move in response to tiny electrical pulses from a scanning tunnelling microscope tip, giving precise control over the motion of individual molecules.

The 'wheels' of the vehicle are made from versions of the molecular rotors that Feringa's group has been developing for several years. They look like small paddlewheels and have a central C=C double bond as the axle. The rotation comes from isomerisation of this double bond and helix inversion as the paddle moves past groups on the chassis of the vehicle.



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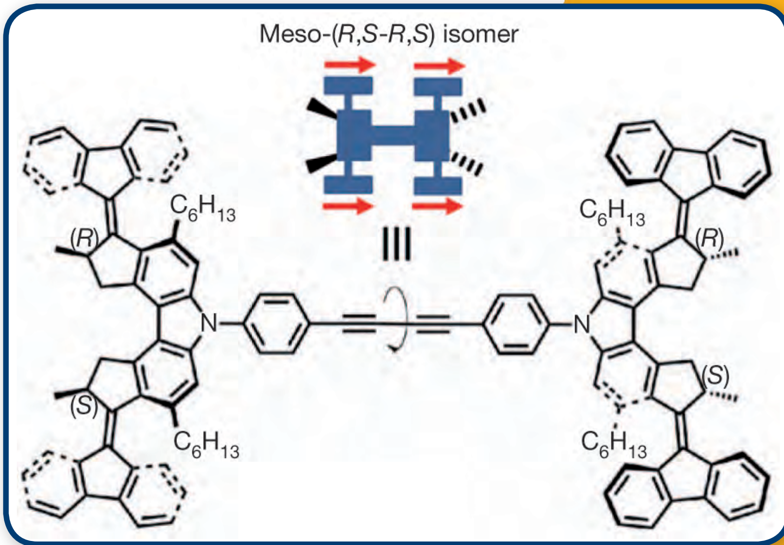


NATURE PUBLISHING GROUP

The molecular vehicle has four paddlewheel rotors that double as wheels

A big challenge

One of the biggest challenges, Feringa says, is to get all four wheels to move together in the same direction. 'Nature doesn't use a single motor, it uses many motors in concert, for example in muscles.' Each wheel rotor only turns one way. They are prepared as mixtures, so only some vehicles have the right combination to move forward. Others will spin around and some will not move at all. While the electrical pulse excites the whole molecule, all four wheels don't necessarily move with every pulse, so its handling is a little unpredictable.

James Tour from Rice University in Houston, US, whose team has produced a variety of nanocars in the past, is very excited – particularly by the way the team managed to get the rotors working together. 'To even get these molecules isolated on the surface in the right orientation is not easy,' he says, 'but then to image them clearly and do the excitations – each of those is an order of magnitude increase in difficulty. It's remarkable and really beautiful work.'

New designs

Feringa is working on different designs of vehicle using the team's experience of different rotor designs. 'This is just our first primitive step,' he says. The next versions could be driven by light, have bigger wheels, or be more precisely controlled in their motion. The team has already demonstrated rotors that can switch their rotation direction or apply a 'brake' to stop completely. Feringa is modest about the prospects, emphasising the difficulty of working at the nanoscale.

For Tour, the impact of the work is more than simply scientific curiosity. 'It takes things that were large hurdles and pushes them down so that other people can enter the field,' he says. 'It has stimulated us to think about new ways we can get our molecules to move.' *Phillip Broadwith*

See it in action

http://goo.gl/fnJrN

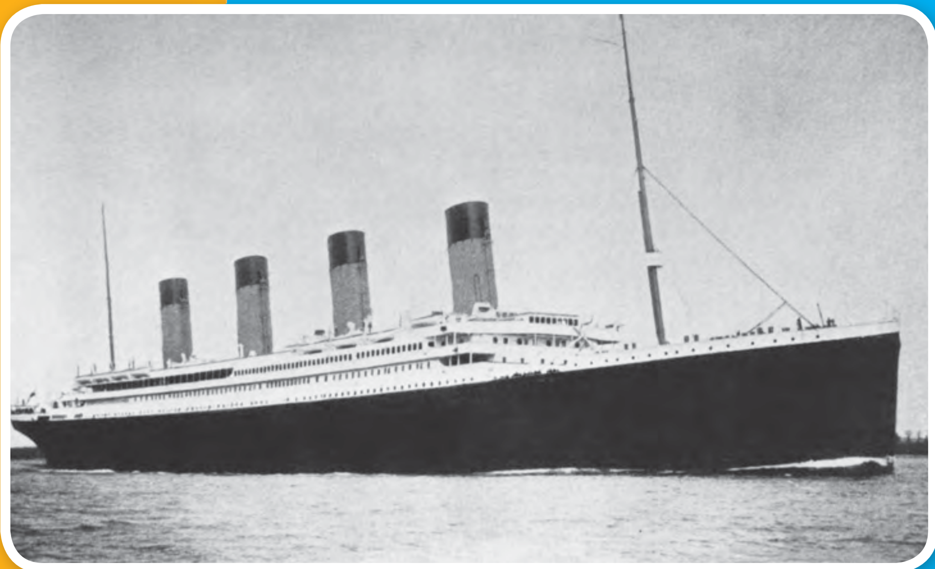
On-screen chemistry

Jonathan Hare explains...

Titanic implications for tiny impurities

Did you know?

At £127 million, the film cost more to produce than the Titanic itself. The cost to construct the ship in 1910–1912 was £1.5 million, equivalent to about £100 million in 1997.



SCIENCE PHOTO LIBRARY

The Titanic leaving Southampton, UK, for her first and last voyage on 10 April 1912

It's 100 years since RMS Titanic collided with an iceberg on its maiden voyage, killing 1517 people.[1] The story was made into the 1997 epic film *Titanic* (starring Leonardo DiCaprio and Kate Winslet) which won 11 Oscar awards and was the first film to earn a billion dollars at the box office.[2] What is the latest scientific thinking about the tragedy?

The Titanic, the largest passenger steamship in the world at the time, was built in Belfast in 1912. It was constructed from thousands of one inch thick mild steel plates and two million steel and wrought iron rivets. She was supposed to be virtually unsinkable. The wreckage site was discovered in 1985 and in October 2011 detailed films were made of the remaining two parts of the ship which now lie half a mile apart in very deep sea.

A number of theories have been put forward to explain why the Titanic sank so quickly. Analysing samples from the wreck, Tim Foecke's group (National Institute of standards and Technology, Maryland, USA) has recently suggested that it may have been simply the chemical composition and material properties of rivets used in the ship's construction.[3]

Chris Topp, a blacksmith in Yorkshire, UK, recreated one of the Titanic's double-riveted hull joints and put it under stresses similar to when it collided with an iceberg

CHRIS TOPP

Impurities

Analysis of fragments of the metal sheets showed that they were of high quality. Analysis of the steel rivets (used in the hull) showed they too had good strength, but the wrought iron rivets (used in the bow and stern) contained an average of three times more slag from smelting than optimal levels. These impurities, being of relatively large particle size, weakened the mechanical properties of the iron making it brittle, causing the ship's metal plates to come apart. With hindsight it now seems that these rivets were loaded dangerously near to their strength limit when the Titanic was built.

Could more have been saved?

Looking back through the 1911 construction company meeting notes they found that the poor quality rivets were sourced from uncertified suppliers in order to build the Titanic on time. Foecke believes that this ultimately led to the relatively quick sinking of the Titanic. They are not suggesting that better quality rivets would have completely saved the ship, but that it might have taken longer for the ship to sink. Timing was everything for the rescue mission. The Titanic took 2 ½ hours to sink and It is believed that if it had taken a few hours longer the death toll would have been much lower.

References

1. *The Titanic* on Wikipedia http://en.wikipedia.org/wiki/Titanic
2. *Titanic*, 1997, Paramount Pictures, 20th Century Fox
3. T Foecke, *Mater. Today*, 2008, **11**, 8

Profile

Claire Wagman

Formulation scientist at Unilever

Clare works on improving the formulation of hair care products. She tells Josh Howgego what it's like to work on products that are seen on supermarket shelves.

Getting ahead

A career in chemistry might be challenging and intriguing but few would consider it glamorous. Claire Wagman's career could be the exception. As a formulation scientist at Unilever, Claire is responsible for working out the best proportions of different ingredients in hair care products like shampoos, gels and styling products. Each formulation has to be just right for its purpose – to cling to hair just the right amount to leave it shiny but not so much as to give a feeling of stickiness. It's sometimes a tough balance to maintain but it is Claire's job to make it happen.

Claire's time is split between the lab, where she cooks up new mixtures of products and in the office and field analysing the results. Newly invented additives can be incorporated into existing shampoo base mixtures, or occasionally, she'll build up a formulation from scratch.

Each batch must be tested. Claire designs trials for each product to assess if it's doing what it needs to. Generally the preparation is loaded onto real hair samples and then trained assessors these and give their opinions. Claire uses statistical analysis to calculate what the best formulation is. Small changes in the formulation can have subtle effects on the end product. She needs to plan effective studies and an ability to think problems through independently.

Juggling projects

Working in a large company like Unilever – one that is responsible for manufacturing many of the household products you'll see on the supermarket shelves – means being involved in several ongoing projects at once. One of the most challenging parts of Claire's job is keeping all of these under control and managing her time so that the results for the most urgent pieces of work are delivered quickly.

Intellectual property is also an issue in corporate workplaces. In the event of a corporate dispute over a product with a competitor, Claire's lab book is a valuable piece of evidence. It can prove where and when a particular experimental result was obtained, which could lead to patents being secured. This means Claire needs really good organisational skills to ensure all her work is accurately documented and filed.

Training and payoff

Companies like Unilever want to help their employees reach their full potential, as having the best people means they can beat their competitors. Claire is given access to great training opportunities. She enjoyed her trip to the US last November for international standard formulation training. Claire enjoys her work and takes pleasure in seeing the skills she developed in her degree to help develop products that will eventually be sold across the country.

You can download The Mole at www.rsc.org/TheMole and copy it for use within schools

Pathway to success

2010–present
Formulation scientist in hair care, Unilever.

2008–2010
Depilatories (hair removal) assistant, Reckitt-Benckiser.

2006–2007
Sandwich placement, quality control chemist, GlaxoSmithKline.

2004–2008
MChem degree at the University of Reading.

2002–2004
A levels in chemistry, biology and geography, St Peter's College, Bournemouth.

What's in your shampoo?

Ever wondered what's in your shampoo and conditioner? Visit http://bit.ly/uniprods **to find out what goes in to all sorts of household products.**

£50 of vouchers to be won

Puzzles

Wordsearch

Find the 32 words/expressions associated with mass spectrometry hidden in this grid (contributed by Bert Neary). Words read in any direction, but are always in a straight line. Some letters may be used more than once. When you have found all the words, use the remaining letters to make a 10-letter word.

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

ACETONITRILE
ATOM
CARBOHYDRATE
CATIONISATION
CHARGED DROPLETS
COMPOUND
COLUMN
DESI
DESORPTION
DETECTOR
ELECTRIC FIELD
ELECTRO SPRAYED
ESI
FAB
HIGH VOLTAGE
HPLC
KINETIC ENERGY
LASER
LASER PULSE
MALDI
MASS ANALYSED
MASS TO CHARGE
RATIO
NITROGEN
ORGANIC MOLECULES
PEPTIDES
PROTEIN ANALYSIS
PROTONATION
PUMP
SPECIES
TIME OF FLIGHT
UV
WEAK ORGANIC ACID

November wordsearch solution and winner

The winner was Zakira Asra. The 9-letter word was PHOSPHATE.

Submit your answers online at **http://goo.gl/cqS4S**

by **Wednesday 1 February**.

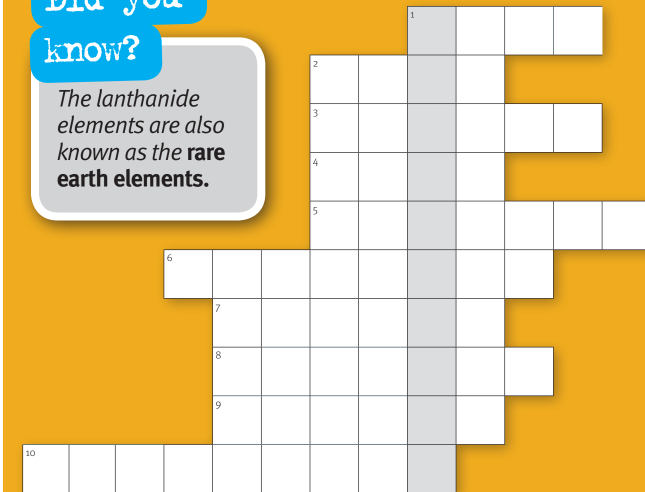
A correct answer for each puzzle, chosen at random, will win a £25 Amazon voucher.

Chemical acrostic

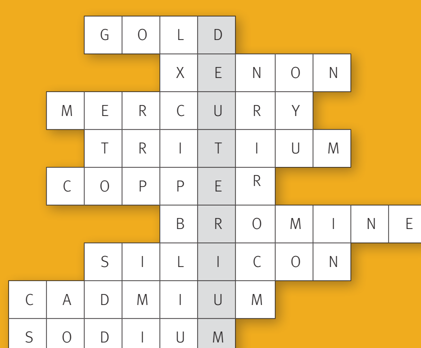
Complete the grid (contributed by Simon Cotton) by answering the 10 clues to find the answer in the shaded box, which is the name of an element in the lanthanide series.

Did you know?

The lanthanide elements are also known as the ***rare earth elements.***



1. A precious metal and symbol of royalty. Some of its compounds are used to treat arthritis.
2. Heavy metal that forms an insoluble chloride and sulfate. Its use in paints, especially for toys, is now prohibited.
3. Too much of this Group I metal may give you high blood pressure, but too little may cause cramp.
4. Most abundant transition metal on the earth; essential to humans, but too little can cause anaemia.
5. Group II metal with an important role in forming the skeletons of living things.
6. Most reactive and dangerous non-metal. Some of its compounds are in toothpaste to prevent dental decay.
7. Heaviest stable halogen. Found in the thyroid gland; deficiency leads to goitre.
8. Least reactive Group I metal. Some of its compounds are used to treat depression.
9. Reactive Group II metal whose compounds are usually poisonous. Insoluble sulfate passes straight through the body. Used to show internal organs in x-rays.
10. Metal burns with very intense light. Part of chlorophyll molecules.



November acrostic solutions and winner

The winner was Marva Jawad from North Manchester Sixth Form.