schools affiliate scheme

CONNECTING TEACHERS TO THE WORLD OF MATERIALS, MINERALS AND MINING

news

Issue 34

Spring Term 2010

In this issue:

What happened to 2009?!

Hello to you all and Happy New Year! By the time you are reading this the Christmas holidays will be a dim and distant memory and I know many of you will be in the grip of the January exams. I hope all your Advancing Physics students sitting their materials module do well and I hope that those that saw one of our talks last term will benefit from the extra information.

In this issue you will find the usual array of articles. Many of you have been in touch regarding the bridge building competition so further details and clarification of the rules and judging criteria are on page 2.

Following on from the success of our previous conferences I am now planning the next one. Nanotechnology – small world, big ideas will be held here at The Boilerhouse in Grantham on Wednesday 13 October 2010. The programme is now more or less fixed and I hope that there is something in it for everyone! Most importantly there will be a session at the end looking at how you can teach nanostuff in school, as this can be tricky to do! Please publicise this event to your colleagues too, they might be interested in attending even if you can't!

The pull-out article in the centre of this issue looks at technical textiles and how they can add functionality to our garments now and in the future. I hope you find this useful – we have had requests from quite a few technology teachers on this subject!

Finally, you can find the latest diary of visits on page 4 and I look forward to catching up with some of you on my travels.

IOM3 The Institute of Materials, Minerals and Mining

This newsletter is written and edited by Dr Diane Aston, Education Co-ordinator. If you have any comments or articles please contact Diane by emailing Diane.Aston@iom3.org or write to her at The Institute of Materials, Minerals and Mining, Grantham Regional Centre, The Boilerhouse, Springfield Business Park, Caunt Road, Grantham, Lincolnshire, NG31 7FZ

The Ultimate Bridge Competition

As you may have read in the previous issue, the Institute of Wood Science (IWSc) merged with IOM3 in summer 2009 creating a new technical division called The Wood Technology Society.

Members of the former IWSc are very keen to see wood and wood-based products promoted and used in schools and they are willing to offer support to teachers to achieve this.

This competition has been designed to bring wood and its uses to the front of the minds of secondary school pupils by getting them to research wood and wood-based products and use their results to design and perhaps construct a novel bridge structure.

The Brief

Students must research the properties of wood and wood-based products and use their findings to design a bridge measuring 700mm long which can span a gap of 600mm. There is no limit on the width or thickness of the structure, but the central 100mm section must be kept clear to allow loading during final testing (only shortlisted bridges need to be constructed and brought along to the final).

Students can use wood, engineered products such as MDF or wood-based materials like card and paper in their design. Glue may be used to stick components together but the use of screws, nails or other metallic fasteners is not permitted.

Entries

The competition is split in to two classes - one for KS3 students and one for those at KS4 (or equivalent) and schools may enter a maximum of 10 entries per class. Students can work individually or in teams of up to 5 people. Entrants must write their category, school name and design name clearly on the back of each poster and submit these along with a completed entry form.

The Prizes

The winning school in each class will be awarded £250 and membership of the Schools Affiliate Scheme (SAS) for twelve months. The school submitting the overall best posters from each class will also receive SAS membership for one year. The winning team members will receive certificates and prizes.

Important dates

Posters must be submitted by 05 March to allow initial judging to take place. The shortlisted schools will be notified by the end of March and the testing day will take place in Grantham in early June.

For more information or an entry form please contact diane.aston@iom3.org.

Judging

- In the first instance entrants must submit two A3 posters detailing their research, choice of materials, construction techniques and drawings of their bridge design. Please do not send bridges!!
- Initially, the judges will be assessing the posters and looking for novel designs which make the best use of the available materials. They will also be looking for clear, well presented posters which show the background to the design and detailed drawings of the bridge.
- The judges will shortlist 3 designs per class per region (Scotland and Ireland, North East, North West, Midlands, South East and South West).
- The shortlisted teams will be invited to bring their bridges along to the final to be tested to destruction.
- During the final the designs will be weighed and then tested by adding weights to the central 100mm section of the bridge. The bridge will be deemed to have failed when it breaks.
- The bridge with the highest strength to weight ratio will be deemed the winning design and there will be one prize per class.

Nanotechnology – Small world, big ideas

This conference is the fourth in a series of events designed to improve teachers' knowledge and understanding of the materials aspects of the curriculum in order to encourage more confident teaching and raise achievement. It will take place at The Boilerhouse in Grantham on Wednesday 13 October 2010, giving you plenty of notice to arrange permission to attend.

The Topic

Nanotechnology is a hot topic at the moment which covers a broad spectrum of materials and research areas. The aim of this event is to give you an insight in to the different types of materials that can be used on a nanoscale, the difficulties associated with processing and handling them and information about their current and future applications.

The conference will be a full day event featuring technical presentations from experts in the field and ideas to improve your teaching of this topic in the classroom.

The Programme

The provisional programme for the day is given below.

0915 to 0945	Arrival and registration
0945 to 1000	Welcome and introduction
1000 to 1100	Plenary lecture
1100 to 1145	Processing materials on the nanoscale
1145 to 1230	Nanotechnology in medicine
1230 to 1315	Nanotechnology in electronics
1315 to 1400	Lunch
1400 to 1445	Nanotechnology in construction
1415 to 1445	Open Q&A session
1445 to 1500	School support from IOM3
1500 to 1515	Tea
1515 to 1615	Nanotechnology in the classroom
1615 to 1630	Feedback and close

The plenary lecture will be given by Professor Alan Smith, a leading expert in the field who has given lectures on nanotechnology to a wide range of audiences all over the world. We are very pleased that he is able to attend and speak at this event. His presentation will give an overview to the topic before the other speakers look at more specific aspects. We hope the day will finish at 1630 at the latest and would encourage delegates to make their travel arrangements with this in mind.

Delegates will also receive a goody bag of information.

The Venue

The Boilerhouse was opened in July 2009 and is the Institute's newest office and conference facility. It is located in Grantham, Lincolnshire and is conveniently located for the A1 with ample free parking available on site. Grantham is also on the east coast main line from London to Edinburgh and the venue is a short walk or taxi ride from the station.

Registration

Attendance at this event is ***FREE OF CHARGE*** for ***any*** teacher at a school that is a member of our Schools Affiliate Scheme. Non-members can join the Scheme for an annual fee of £30 and attend for free, or pay a £50 non-member delegate fee. The event has been designed to link in with the science curriculum, though it will also be of general interest to teachers from other departments. If you are unable to attend, please tell colleagues, both from your department and others, as they might be interested in coming along.

You will find a flyer and registration form enclosed with the newsletter, alternatively contact diane.aston@iom3.org.

The SAS Pages...

Visit diary

The autumn term was a busy one with us visiting a total of 43 schools to deliver 90 sessions to over 3200 students and teachers. The spring term is also looking busy and although I am fully booked, Toby still has a number of spaces available. Although his priority is giving talks on the minerals and mining aspects in the curriculum he may be able to offer some materials visits. If you would like to find out the dates he has available or indeed book a visit please contact Sarah Harrison by emailing sarah.harrison@iom3.org.

January		12	William Beaumont School
7 to 9	ASE Meeting, Nottingham	16	University of Wales, Caerleon
11	Spennymoor School	23	Wakeman School
12	Newstead Wood School	24	Highfields School
13	The Whitby High School	26	Penair School
14	Sale Grammar School	26	Mullion School
19	Edinburgh University	**March**	
21	Worthing College	03	Woolston School
22	Penketh High School	05	SSERC Meeting, Dunblane
25	Cardinal Vaughan School	08	Alderley Edge School
26	Coppers Company and Coburn School	08	Yale College
27	Tameside College	10	King Edward VI College
February		10	Cranbrook School
01	Shrewsbury High School	12	QEGS, Penrith
03	Blundell's School	15	Sellafield Schools Day
04	Halliford School	16	St Bede's College
09	Bradford College	25	Hagley College
10	Sidcot School	31	St George's College
Visit by Diane Aston or Toby White			

SAS Resources

I can only apologise to you for the fact that the 2009-2010 resource on bridges is still not with you. It is in production and I am hoping that it will be with you before half-term in February.

We are starting to think about the resource for the new academic year for schools joining or renewing their membership of the Scheme in 2010-2011. We have decided to do something relating to materials in sport so that you can get the topics incorporated into your teaching prior to the London Olympics in 2012. We are planning to do something a little bit different this time to tie in with the responses we have had from teachers in their renewal questionnaires. The resource will consist of a number of Power Point presentations and articles on the materials used in different sporting applications and these will be accompanied by posters on similar topics We would value your input at this early stage so that we can design something to meet your needs. Any suggestions will be gratefully received! Please email them to diane.aston@iom3.org.

Education Web-pages

Over the past few months I have been writing the content for our new pages on the Education and Training section of the IOM3 website (www.iom3.org). The Schools Affiliate Scheme micro-site will be launched later in the Spring term and will include a member's only area where you can access back copies of the newsletter, conference reports and some previous resources. I will be writing to you shortly with your login and password details so please do have a browse!

Staffing news

The youngest member of the Education Team will be arriving on or around 08 April which means I will be going off on maternity leave again! We are in the process of setting up a Scheme to recruit Ambassadors to give materials talks in the future so please watch this space.

Education Committee

We are looking to recruit new members to represent the views of science, technology and geology teachers in schools and colleges. We meet roughly three times per year and will pay your travelling and cover expenses to attend meetings. If you are interested in finding out more please contact diane.aston@iom3.org. Our next meeting is planned for mid-June and the one after that for mid-September.

Big things happen with The Smallpeice Trust:

Finding young engineers of the future

The Smallpeice Trust has teamed up with a host of leading businesses and institutions to launch a challenging and innovative timetable of national courses in 2010 for young people. These short residential courses are all designed to inspire the next generation of engineers and provide a fun foundation for learning whilst proving that engineering is in fact evident in almost every aspect of daily life.

Most of the courses take place in the summer, although some take place at other times in the year in January and March. All courses are designed to take students interest in engineering a step further with emphasis on creativity, design and team working. Subjects include: Biomedical Engineering, Low Carbon Energy, Marine Technology, Materials Technology, Mining & Minerals, Nanotechnology, Nuclear Engineering, Sports Materials, and Power Engineering.

At the University of Manchester students can attend two courses, Engineering Materials and Sports Materials. The first allows Year 10 students (aged 14/15) to discover the breadth of materials science with practical workshops exploring not just engineering materials but also biomedical materials science and technical textiles. The second course, gives students in Year 12 (aged 16/17) a fascinating insight into the science behind sport and the opportunity to design-and-make their own high performance sporting textiles.

The established Mining and Minerals course will be running again at University of Exeter (Camborne School of Mines), for Year 11 and 12 students (aged 15-17). The course provides students with a firm insight into the earth's natural resources including gold, diamonds, coal, oil, clay, granite and limestone. Sponsored by two of the largest mining companies in the world – Rio Tinto and Anglo American, students will have the opportunity to visit quarries and see first-hand a modern mining operation in action.

All Smallpeice courses are linked to the National Curriculum and Every Child Matters framework. By attending one of our courses students will gain experience of university life and industry that will accelerate their personal development and their potential for greater academic achievement.

For further information on the programme of courses, visit www.smallpeicetrust.org.uk or call 01926 333200.

A wide range of other taster courses of varying length are also available, for your students. Some of these give a general introduction to engineering and others look more specifically at particular disciplines. You can find out more by visiting www.headstartcourses.org.uk and www.insightcourses.org.uk .

Summer Term Courses for Teachers

I know I bang on about this every year but the summer term really does offer a wealth of opportunities for you to improve your knowledge and understanding of materials by attending one (or more!) of the many courses that are organised at this time.

The speakers on these courses have been chosen for their expertise and enthusiasm and the topics for their relevance to the science and technology curriculum. Some of the courses are free to attend but others may carry a small charge to cover the cost of administration.

Polymer Study Tours

These three and a half day residential courses are run at three centres around the UK towards the end of the summer term and are aimed at secondary science and technology teachers. They offer delegates the opportunity to update their knowledge of all things polymer related and feature a mix of lectures, workshops, practical sessions and industry visits. The provisional dates for the 2010 courses are as follows:

London Metropolitan University:	20 to 24 June
Edinburgh Napier University:	27 June to 01 July
Manchester University:	11 to 15 July

For more information about the Polymer Study Tours please contact Colin Hindle by emailing c.hindle@napier.ac.uk.

RSC Materials Summer School

This residential course is aimed primarily at secondary Chemistry teachers and offers the chance to look at a wide variety of current materials topics at a number of venues. Based in London, the course has sessions in the materials departments of Imperial College, London Metropolitan University and Queen Mary (University of London) which look at biomaterials, nanotechnology, and fuel cells to name just a few. There are also visits to the National Gallery and V&A Museum to look at how materials and chemistry feature in maintaining and renovating exhibits.

In 2010 the course will be running from 04 to 07 July and you can find out more information by visiting www.rsc.org/Education/Teachers/INSET/SummerSchools.asp

Goldsmiths Materials course for teachers

This course will be running from 18 to 23 July in the School of Metallurgy and Materials at the University of Cambridge. It is aimed at physics and chemistry teachers and is designed to improve their knowledge and understanding of a broad range of materials. The course features lectures and practicals on the fundamentals of materials (microstructure and mechanical properties) along with specific applications such as aerospace materials and integrated circuits. The course also includes visits to Duxford Air Museum and local industry. For more information visit http://www.thegoldsmiths.co.uk/education/course_detail.php?education_id=12

Autumn Open Days

Don't forget that in the autumn term we will once again be organising the November Open Days at Universities all over the UK. It is hoped that the next season will feature more venues than ever so that wherever you are you will have easy access to an event. The dates for the 2010 programme should be available by the end of March and will be published in the next newsletter and on the website. I will also be sending out booking forms after Easter so watch this space and remember to book early!

Technical Textiles

Over the past few years I have received a number of enquiries from technology teachers specialising in textiles about the use of smart and technical textiles and their uses. In this article I hope to answer a few of these queries by providing some information about the sorts of materials used and their applications

Traditional textiles?

Textile materials made from natural fibres such as cotton, wool and linen have been used for many centuries. The addition of man-made fibres such as nylon and polyester in the last fifty years has allowed manufacturers to create fabrics which crease less, fit closer to the body and dry quicker.

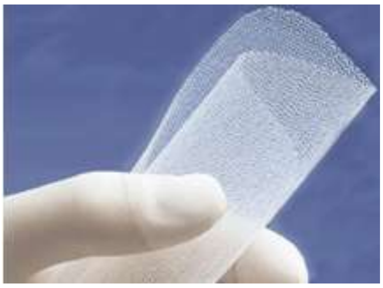
In recent years there has been a resurgence in the use of natural fibres in the textiles industry, but many of these come from more unusual sources. Bamboo is becoming increasingly popular as it produces a lightweight cloth which is very soft, breathable, good for controlling temperature and antistatic. These properties arise from the structure of the bamboo fibres, which have a round cross section and contain many small micropores. It also has antibacterial properties and is UV resistant. Bamboo is a sustainable material and is one of the fastest growing plants in the world. It requires very little management once planted and will reach its maximum height in 3 months and maturity within 4 years. Bamboo also helps to promote soil stability as it is harvested by cutting rather than uprooting. A wide range of bamboo products are now available including towels, bedding, clothing and reusable nappies.

T-shirt and reusable nappy made from natural bamboo fibres

Conventional textiles in unconventional applications

Many conventional textiles are used in applications such as medicine where they are incorporated into a range of devices for use both inside and outside the body. Of course the most important factor here is biocompatibility and many of the materials used are based on synthetic polymers. Artificial blood vessels which are used to either reinforce or replace natural tissues are commonly made from polyester fibres. These fibres are woven very carefully to ensure that the tube is flexible along its length but not around its circumference, to allow the patient to move and blood to pulse through the vessel. In some cases the artificial blood vessels are coated in PTFE to reduce the risk of clotting. A knitted mesh made from monofilament polypropylene fibre is commonly used to reinforce and support the area of an inguinal or femoral hernia. This is fastened in place using dissolvable stitches made from materials such as silk or polylactic acid. Non-dissolving stitches may be made from monofilament nylon or polypropylene thread.

Artificial blood vessels made from woven polyester



Polypropylene mesh fabric for reinforcing the site of a hernia.


Marquee roof made from reinforced PVC fabric.


Boeing 787 Dreamliner – the first civil aircraft to have a complete carbon fibre composite fuselage.


Carbon fibre composite bicycle frame, offering strength, stiffness and low weight.

Protective suit made from woven Kevlar offers protection from cuts and abrasions.

Modern fibres and their uses in composite materials

In recent years composite materials have become increasingly popular as they combine the best properties of each constituent material. Although a wide range of composites are available the most commonly used are made by reinforcing some sort of polymer with some sort of fibre. The polymer matrix could consist of a thermosetting polymer such as an epoxy resin or a thermosoftening polymer like PVC or polypropylene. The reinforcing fibres may be made from glass, carbon or Kevlar and the size, ordering and proportion of fibres will control the overall properties of the composite. In many engineering applications the fibres are woven together to produce cloth or matting and the properties can be controlled by varying the number of fibres in the warp and weft and the way in which the layers of fibres are layered up during construction. Glass fibre reinforced PVC is a relatively soft and flexible material and is ideally suited to making awnings and coverings for walkways to provide shade. Carbon and Kevlar cloths are used in composites for a wide range of applications in the aerospace industry and the manufacture of sports equipment.

Textiles with added functionality

Many modern textiles have been designed to provide added functionality. This could be something as simple as a material with better water wicking qualities or a material that is flame retardant. Trade names such as, Gore-Tex, and Kevlar are used in relation to fabrics and these have different properties which lend themselves to specific applications.

Garments containing Gore-Tex fabrics are 100% waterproof but at the same time breathable. They are made by encasing a layer of Gore-Tex fabric between layers of other high performance fabrics which are application dependent. The seams are sealed with tape to ensure that the tiny holes created during stitching are covered. The Gore-Tex consists of a layer of expanded PTFE membrane which contains over 1395 million pores per square centimetre. These pores are 20,000 times smaller than water droplets so they prevent penetration of rain. However, they are 700 times bigger than molecules of water vapour so sweat can pass through and keep the wearer comfortable. This membrane also has an oleophobic coating which repels oils, making the fabric stain resistant to food spills, cosmetics and insect repellents.

Kevlar is the trade name for a type of polymer called and aramid and it was developed by DuPont in the 1960s. It is very light and strong and is available in the form of fibres and yarns that can be woven or knitted into cloth. The material has exceptional resistance to cuts and abrasions and is therefore highly suitable for protective clothing such as suits, trousers, aprons and gloves. Kelvar may be woven alongside conventional textiles such as denim to make protective clothing for motorcyclists. It is also fire resistant and can be used in upholstery and for protective garments.

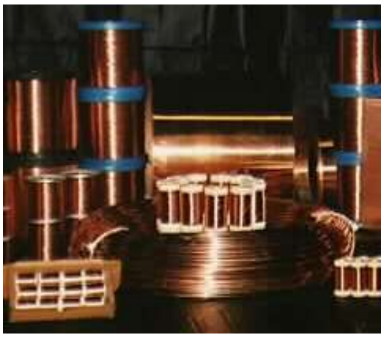
Textiles incorporating electronics

Textiles incorporating electronics could be used in for wide variety of applications from real time health monitoring to mobile communication and gaming. Generally speaking the electronics function is built into the textile by incorporating some type of conducting thread. This could be made from copper, carbon or silver coated nylon (which also has the advantage of having antimicrobial properties) and it may be used to create a circuit to conduct electricity for power, heating or signal transmission. The wire may also form an antenna which can transmit or receive radio signals. Microcontrollers may also be incorporated into the fabric to perform specific functions and displays made from flexible materials may be used to convey messages. The power supply for these electronic functions may be provided by a small battery pack or flexible solar cells which can be incorporated into the garment. Energy harvesting using piezoelectric materials may also be incorporated into clothing or footwear to provide power for portable devices.

It is also possible to incorporate sensors into textiles which can monitor movement, respiration and heart rate. Garments using such technology may be used to monitor health in real time and transmit information back to a central computer. One such system is the WEALTHY suit which comprises a normal close fitting, flexible garment that has been fitted with electrodes which can measure the wearers' heart rate and temperature and piezoresistive sensors in the arms and abdomen to detect movement. Data from these sensors is passed to a small portable electronic device attached to the garment, which transmits the information back to healthcare professionals. A vest containing a knitted stretch sensor has also been developed for sports and outdoor applications, which monitors the wearer's respiration rate.

Textiles incorporating smart materials

Smart materials include a broad range of technologies which are being used in textiles-related applications. Some of these have been around for many years but others are new and just starting to find a place in the market.



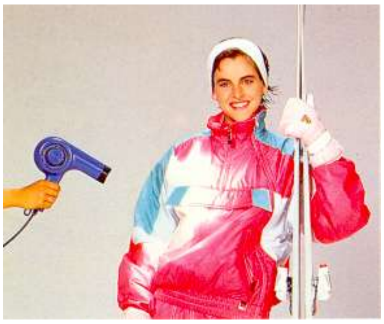
Thread made from copper wire may be woven into conventional fabrics to create a conductive path.

Thermal socks containing conductive thread through which a current is passed to give a heating effect.

Jacket with integrated digital display consisting of LEDs mounted on to a flexible conducting material.

Flexible solar panels have been incorporated in to shoulders and back of this jacket to provide power for portable devices.

Thermochromic materials in textiles



Ski jacket incorporating thermochromic yarn which changes colour when heated.

Thermochromic polymers are designed to change colour with a change in temperature. One of the major supermarkets recently launched a range of heat sensitive baby clothes which incorporates a label which changes colour if the child's temperature rises above normal.

QTC in textiles

Soft switch built into the sleeve of a jacket uses QTC to control an MP3 player in the wearers inside pocket.

Quantum Tunnelling Composite (QTC) is made by mixing a fine metal powder with a polymer resin and has the interesting property that its electrical resistance varies with applied pressure. This property allows simple switches and sensors to be created which can easily be incorporated into garments to give added functionality.

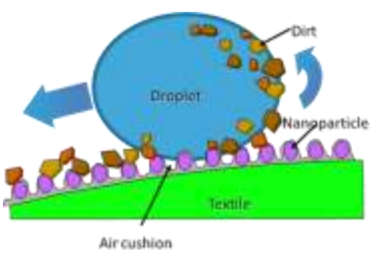
SMAs in textiles

Shape memory alloys such as Nitinol can be woven alongside conventional textiles to produce fabrics which have improved crease resistance. Creases can be removed from the fabric by simply heating with a hair dryer to activate the memory of the very fine diameter wires.

Crease-resistant SMA shirt made from very fine Nitinol wire.

Nanoscale coatings on textiles

Textiles can be surface treated to give them stain resistance and water repellent properties. These coatings are referred to as superhydrophobic and they consist of minute particles attached to the surface of the textile. When water droplets hit and roll down the textile they cannot wet the surface as they are repelled by the coating. As the droplets move and run off the fabric they remove dirt particles with them. A number of commercially available garments are now using this technology, including school uniforms!



Schematic diagram showing how a nanoscale superhydrophobic coating on fabric repels water and improves stain resistance.

Where can I find out more?

There are a large number of sources of information out there if you are willing to spend hours trawling the web. I found these sites quite useful when compiling this article:

http://www.bambooclothing.co.uk/why_is_bamboo_better.html

http://www.tensilefabric.co.uk/fabric-structures/fabrics.aspx

http://www.shadeengineering.com.au/fabricspecs.html

http://www.boeing.com/commercial/787family/index.html

http://www.Gore-tex.co.uk

http://www2.dupont.com/Kevlar/en_US/index.html

http://www.flamesafetyapparel.com/cut_resistant_kevlar.html

http://www.madeformums.com/baby/heat-sensitive-baby-clothes-launched-by-asda/1715.html:

ARMOURERS & BRASIERS' COMPANY

The Company is keen to encourage and support materials-related teaching at school level. The following activities will be sponsored in 2010. Fuller details will be published in February in the leaflet '*Resources for Materials Teaching in Schools'* and in the Company's website: www.armourersandbrasiers.co.uk

Summer School on 'The Science of Materials': residential course in *London* for teachers of chemistry at pre- and post-16 levels. *Contact* : 0207 440 3350 (education@rsc.org)

Updates for Physics Teachers at *Southampton*, *Sheffield* and one other university for all teachers of physics. Each course contains a lecture, and often practical work, on materials science. *Contact*: Manchi Chung 0207 470 4820 (manchi.chung@iop.org)

Master Classes in Materials Science/Engineering: residential course at *Birmingham University* and day works visit to Rolls-Royce, *Derby,* for teachers of chemistry, physics, technology and general science at pre- and post-16 levels.
Contact: Erica Tyson 01332 248654 (erica.tyson@rolls-royce.com)

Teachers' Conferences: one-day conferences on aspects of materials in the National Curriculum. There will be one on 'Nanotechnology' in October 2010. *Contact*: Dr. Diane Aston 01476 513882 (diane.aston@iom3.org)

Headstart Courses in Materials: residential courses for 17 year-olds on materials science at *Oxford University*. *Contact*: Diane Taylor 01865 273709 (diane.taylor@materials.ox.ac.uk)

Materials Science in Salters' Chemistry Camps: materials science talks and practical activities in these well-established residential Camps run by the Salters' Institute for 15 year-olds at *Heriot-Watt, Manchester* and *York Universities*. *Contact*: Stephanie Amos 0207 628 5962 (camps@salters.co.uk)

Equipment Grants for Schools: grants for science equipment and projects up to £600 for primary schools and to £1000 for secondary. *Contact*: The Clerk, Armourers' Hall 020 7374 4000 (clerk@armourersandbrasiers.co.uk)

Armourers/Corus Sixth Form Scholarships: scholarships at £350 for sixth-formers considering materials science at one of the universities *Birmingham, Cambridge, Imperial, Leeds, Liverpool, Loughborough, Manchester, Oxford, Queen Mary, Sheffield and Swansea*, and continuing to B.Eng or M.Eng. level. *Contact*: Carolyn Green 0121 414 5175 (c.a.green@bham.ac.uk)

Entry Scholarships for University Materials Courses at *Birmingham, Leeds, Liverpool* and *Swansea*. *Contact*: individual university departments for details.

Who are they?

The Worshipful Company of Armourers and Brasiers' is one of the original livery companies of the City of London.

The Guild of St George of the Armourers was instituted in 1322 to lay down regulations for the control of the trade and its first Royal Charter was granted by King Henry VI in 1453.

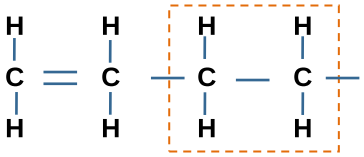
The Company's current charter was granted by Queen Anne in 1708 to give the Brasiers (workers in brass) equal status within the Company, though they had been working together since the 16th century.

The majority of the Company's charitable giving is now directed to supporting materials science and engineering. Through the Gauntlet Trust the Company provides support for all stages of education from primary schools to courses for secondary teachers, scholarships for UG students, travel bursaries for postgrads and the Venture Prize for materials science research.

For more information visit www.armourersandbrasiers.co.uk

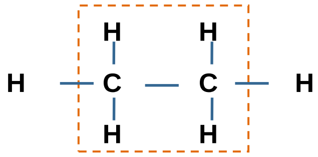
Ultimate Guide to Polymers Part I

In the previous three issues of the newsletter this article considered strengthening mechanisms in metals. I thought it might be a nice idea to have a detailed look at all the different groups of materials in this way and we are starting in this issue with the first article on polymers. This article focuses on the types of polymers and in the next two issues their structure, properties, processing and uses will be explored.

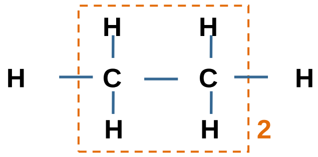


Removal of the double bond from the ethylene monomer (left) produces the ethylene repeat unit or 'mer' (right) which has active sites on each end and is able to form chains

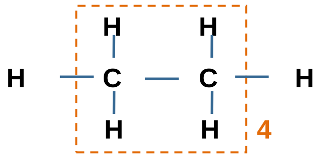
The properties of the resulting compound depend on the number of times this 'mer' is repeated. When the chains are capped with hydrogen atoms alkanes are produced.



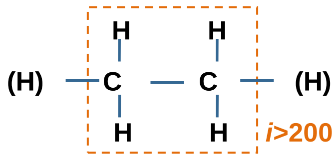
When the molecule consists of one capped 'mer' the result is ethane gas (m.p. -172 °C, b.p. -89 °C), above.



When the molecule consists of two capped repeat units the result is butane gas (m.p. -135 °C, b.p. -0.5 °C).



When the molecule consists of four capped repeat units the result is n-octane liquid (m.p. -135 °C, b.p. 125 °C)



Above a critical number of repeat units neither the end groups nor the chain length affect the properties very much and the resulting materials are known as polyethylenes. Linear polyethylene is a solid, m.p. ~130 °C.

What is a polymer?

Polymers are a group of materials which dramatically changed the world that we live in during the 20th century. They are a group of materials that have become associated with many low-tech, high volume applications such as food packaging and textiles, though they are also used in many more high tech, low volume applications in medicine and electronics. When we think of polymers in this sense, we essentially mean synthetic, organic compounds produced from oil; natural polymers originating from plants, such as cellulose and rubber, have been used for many centuries.

The term 'polymer' was first used in 1833 by the Swedish chemist Jöns Jacob Berzelius, though his definition differs from that used today. The word was derived from the Greek words ***poly*** meaning many and ***meros*** meaning parts and this is essentially how a polymer is defined today.

A polymer is defined as a long chain molecule built up by the multiple repetition of small (often simple) repeat units or ***mer***. These molecules are covalently bonded and their properties are controlled by their molecular structure and microstructure. This concept was first proposed in the early 1920s by Hermann Staudinger though it took over a decade to become widely accepted and it eventually won him a Nobel Prize. The length of the molecules, and therefore their molecular weight, helps to determine the properties and indeed state of the material. The diagram on the left shows how increasing the number of ethylene repeat units changes the properties of the resulting material. Branching of the main carbon chain can also affect the properties.

Polymers can broadly split into three different types: thermosoftening polymers or thermoplastics, thermosetting polymers and elastomers. Each of these groups has a different structure and therefore different properties, and each lends itself to particular types of applications.

Thermosoftening polymers

These are the simplest type of polymers and are comprised of covalently bonded long chain molecules which are held together by Van der Waals forces, dipole-dipole interactions or hydrogen bonding. They are characterised by their ability to be softened and melted by the action of heat, allowing them to be shaped repeatedly.

Thermoplastics are usually defined as either amorphous or semi-crystalline (often just called crystalline). These terms relate to the amount of ordering within the structure, which is controlled by the shape and size of the molecules. The properties also depend on whether the polymer is being used above or below its glass transition temperature (see box right), a phenomenon which affects the amorphous portion of the material.

Thermoplastics include polyethylene (LDPE and HDPE), polypropylene (PP), polyethylene teraphthalate (PET) or polyester, polycarbonate, polystyrene, polyvinylchloride (PVC), polymethyl methacrylate (PMMA), polyurethane (PU), polytetrafluroethane (PTFE) and even Nylon, Kevlar and Lycra (all types of polyamide)

Thermosetting polymers

Thermosetting polymers are again made up from long chain molecules but in this case the molecules are irreversibly bonded together by cross-links which create a rigid 3 - dimensional network. The cross-linking is achieved by curing (application of heat) or a chemical reaction and this locks the structure together, preventing the material from softening and melting on heating (this makes them materials that are pretty much impossible to recycle). Prior to cross-linking the materials are usually either a liquid or malleable solid which can be poured or shaped in a mould. Once the cross-linking reaction has taken place a solid, rigid component is produced.

Commonly used thermosets include epoxy resins, melamine resin, Bakelite, vulcanised rubber and urea formaldehyde.

Elastomers

Elastomers may be either thermosoftening or thermosetting and are usually characterised by their ability to stretch to many times their original length. The long chain molecules have a disordered or amorphous structure but they are bonded together by cross-links. They are generally used in the rubbery state above their Tg but become brittle below Tg.

Commonly used elastomers include natural rubber, polyisoprene, butyl rubber, polybutadiene, nitrile rubber, chloroprene and silicone rubber.

Glass Transition Temperature

The transition from solid to liquid is pretty clear cut in most materials - it happens at the melting point. However, amorphous polymers undergo an additional transition called the Glass Transition. The glass transition temperature, or **Tg**, is below the melting point of the polymer and is the point at which the randomly oriented polymer chains have sufficient energy to become mobile. Thus below Tg the material will tend to be stiff and brittle, but above Tg it becomes more flexible and ductile. This why the properties of some commonly used polymers vary with temperature – Tg is within the normal operating temperature range.

Above the Tg the material is described as being in a rubbery state and below the Tg it is said to be in a glassy state.

Thermoplastics are able to be reshaped by heating to above Tg, applying deformation and then cooling and it is possible to do this a number of times.

Where can I find out more?

The following sites contain some useful information

http://en.wikipedia.org/wiki/Polymers
http://pslc.ws/mactest/tg.htm
http://www.eng-tips.com/faqs.cfm?fid=957
http://scifun.chem.wisc.edu/CHEMWEEK/POLYMERS/Polymers.html
http://www.cem.msu.edu/~reusch/VirtualText/polymers.htm
http://openlearn.open.ac.uk/course/view.php?id=2937
http://en.wikipedia.org/wiki/Thermosetting_polymer
http://en.wikipedia.org/wiki/Elastomers

The Bloodhound SSC Project

The Bloodhound SSC project is aiming to design and build a jet engine and rocket powered car that can achieve a top speed of over 1000mph, breaking the current land speed record by 31%. It is hoped that the construction of the car and initial trials will take place in 2010 with the record breaking run planned for 2011.

The project is the brainchild of Sir Richard Noble, the current holder of the record in Thrust SSC. However, breaking records is not the only aim of the project. The team hope to inspire the next generation of scientists and engineers and encourage students to study these subjects.

The Bloodhound SSC website, www.bloodhoundssc.com, contains masses of information about the project but also has links for schools. A range of resources looking at different aspects of the project have been developed, which are aimed at KS3 and KS4.

Minerals and Mining update

This time last year quite a number of schools and colleges took advantage of the sponsorship, offered by Anglo-American and Rio Tinto, to join the Schools Affiliate Scheme. I hope you have found the Scheme useful and will decide to renew your membership this year for the small sum of £30. The vast majority of schools who take advantage of the free visit renew each year, because they see the value of what we offer and how it relates directly to the Geology specifications. Can I ask that if you are not yet convinced about the Scheme, then please request a visit and see for yourself? I 'm sure you won't be disappointed. You can download a list of the available talks from: www.iom3.org/content/schools-affiliate-scheme

I know that a great number of Geology teachers already make use of local quarries and mines as resources for field trips. If you would like help or advice in organising a visit then you can contact the Mineral Products Association (formerly QPA) through www.mineralproducts.org. Take a look at the teaching resources they have in the Youth Zone.

As most of you know, I work part-time at IOM3 and part time in the Mining group at the University of Leeds. The sad news is that the Mining and Quarry Engineering degree course at the University of Leeds is no longer being offered due to the low number of students over the last few years. The current first year, who started in September 2009, will complete in 3 or 4 years time, but we are not recruiting for 2010. This means that CSM at Exeter University is the only place in the UK offering an undergraduate mining engineering course, which is continuing to run very successfully. You can find out more about the course by visiting www.exeter.ac.uk/cornwall/academic_departments/csm/

However, it is still possible to study Chemical and Mineral Engineering at Leeds, which equips the students for work in the processing sector of the minerals industry (more information at (http://www.engineering.leeds.ac.uk/ug/courses/tem13.shtml).

There are also a number of applied and resource geology courses around the country which focus on the mining and minerals industries, a full list of which can be found on the UCAS website, www.ucas.ac.uk.

Despite the global economic downturn, there are still lots of opportunities and good salaries to be found in the minerals and mining sector – so pass it on to your students!

Where does chromium come from?

Although chromium was discovered in the mineral crocite (lead chromate), it is only commercially extracted from the mineral chromite; an iron chromium oxide ($FeCr_2O_4$), although the iron can be partly replaced by magnesium. When a rock is composed predominantly of the mineral chromite, it is known as chromitite!

The method of processing depends on the final product. In the case of **pure chromium**, the iron has to be separated from the chromium in a two-step roasting and leaching process. The chromite ore is heated with a mixture of calcium carbonate and sodium carbonate in the presence of air. The chromium and iron are both oxidised as shown below.

$$4\ FeCr_2O_4 + 8\ Na_2CO_3 + 7\ O_2 \rightarrow 8\ Na_2CrO_4 + 2\ Fe_2O_3 + 8\ CO_2$$

Subsequent leaching at high temperatures using sulphuric acid dissolves the chromates and leaves the insoluble iron oxide.

$$2\ Na_2CrO_4 + H_2SO_4 \rightarrow Na_2Cr_2O_7 + Na_2SO_4 + H_2O$$

The dichromate is then converted to the chromium(III) oxide by reduction with carbon

$$Na_2Cr_2O_7 + 2\ C \rightarrow Cr_2O_3 + Na_2CO_3 + CO$$

Then finally, it is reduced in an aluminothermic reaction to chromium.

$$Cr_2O_3 + 2\ Al \rightarrow Al_2O_3 + 2\ Cr$$

The other main product is **ferrochromium** (FeCr), where the iron and chromium do not need to separated, because they are both required in the manufacture of stainless steel. This can be produced by simple reduction of chromite ore in electric arc furnaces or small smelters, with either aluminium or silicon as the reducing agent at high temperatures.

By far the largest producer of chromium ore is South Africa, which accounts for over 40% of the world's production. This is due to the presence of large amounts of chromite in what is called the Bushveld Igneous Complex (BIC). This is the world's largest known layered igneous intrusion with an area the size of Ireland. It has been tilted and eroded and now outcrops around what appears to be the edge of a great geological basin. The BIC contains some of the richest ore deposits on in the world, including vast quantities of iron, tin, chromium, titanium and vanadium, and the world's largest reserves of platinum group metals. The BIC contains about 70% of the world's reserves (proven, accessible, economic resources) of chromite.

The BIC was formed about 2 billion years ago, when vast quantities of molten rock from the earth's mantle were brought to surface through long vertical cracks in the earth's crust. The crystallisation of different minerals at different temperatures, which then settled into distinct layers, resulted in the formation of a structure rather like a layered cake consisting of distinct rock strata referred to as "reefs".

Chromitite (black) and anorthosite (light grey) layered igneous rocks in the BIC. (From wikipedia: http://en.wikipedia.org/wiki/Bushveld_Igneous_Complex)

Virtually all the chromite in south Africa is worked by underground mining methods.

Underground chromite mining at Samancor project in South Africa (from www.mining-technology.com/projects/samancor/

Chromite is also mined in India, Kazakstan and Finland, where surface mining methods are used in the project at Kemi.

Surface chromite mining at Kemi project in Finland (from www.mining-technology.com/projects/kemi/)

CHROMIUM

V	Cr	Mn
Nb	Mo	Tc

- Chromium has atomic number 24 and atomic mass 51.99. It sits between vanadium and manganese and above molybdenum in the first transition series of the Periodic Table.
- It has a density of 7.10gcm^{-3}, melts at 1907°C, boils at 2671°C and is a body centred cubic solid at room temperature.
- Chromium is a steel-grey lustrous metal which can take a high polish. It is relatively hard but malleable and many of its applications are due to its excellent corrosion resistance.
- Chromium becomes rapidly passivated by oxygen when exposed to air. This stable oxide layer has a spinel structure and is only a few atoms thick, yet it is dense enough to prevent further diffusion of oxygen to the underlying material.
- It is the 21st most abundant element in the Earth's crust and occurs at an average concentration of 100ppm.
- One of the first known uses of chromium dates back over 2000 years. The bronze tips of cross bow bolts belonging to the Terracotta Army of the Qin Dynasty in China were found to be coated in chromium which left them untarnished.
- In modern times chromium was first discovered and extracted by Louis Nicolas Vauqueline in 1797 in the mineral crocoite (lead chromate).
- Annual production of chromium amounts to around 4.5 million tonnes and 85% of this is used in alloying and plating.
- Chromium is added to steels in the form of ferrochromium. In tool steels a concentration of 3 to 5% by weight is added and stainless steels require the addition of around 18wt% chromium along with 8 to 10% of nickel. It is also added to nickel-based superalloys where it forms stable carbide particles which provide grain boundary strengthening.
- Electroplating with chromium provides a corrosion resistant coating which can be polished to a high surface shine.
- Chromium has many possible oxidation states of which 3+ is the most stable. Pigments containing chromium compounds can be a variety of colours, including chromium yellow (based on lead chromate) which was for many years used to paint school buses.
- The inclusion of a trace amount of chromium in corundum and beryl gives rubies and emeralds their characteristic red and green colour respectively.