Cambridge material eyes

Autumn 1996 Issue 2

Sweet Success

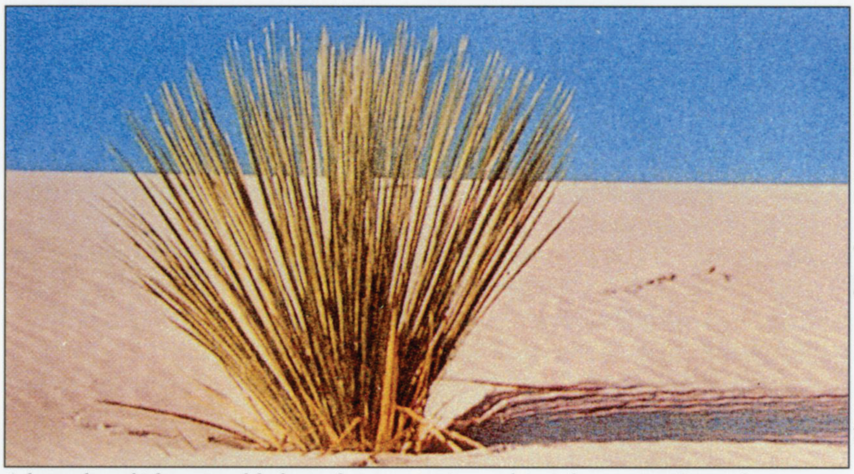


Photo: courtesy of Professor Felix Franks at Pafra

A desert plant which survives dehydration by converting its starch into glassy sugars. Some saltwater worms do the same thing: when dried out they transform into an amorphous state so glass-like that they can shatter on impact. Once it rains, they resume their life functions.

What is the connection between sugar, spaghetti, boiled sweets and worms? If you guessed the answer, it is probably as a result of talking to Dr Lindsay Greer about his unusual work in the field of amorphous materials (that being the connection). Dr Greer has recently completed a joint project with Pafra BioPreservation (on the Cambridge Science Park) to develop a new method of drugs storage. The project was concerned with copying nature's strategy for preserving life in the face of dehydration. If, when living things dry out, a glass is formed rather than crystals, degradation is prevented, there is no atomic mobility and life can return on re-hydration.

Many medical drugs are unstable and in the extreme case, may have a life of only a few minutes. This means that they need to be kept chilled or even deep frozen to have a usable shelf life; but this is not always feasible in hot countries. If these drugs could be readily dried, the dried pellets obtained could be re-hydrated and injected. By buffering the drug solutions with various sugars before drying, the natural processes used by plants and simple organisms can be mimicked and glassy sugars formed, thus avoiding the damaging solute partitioning which would inevitably accompany crystallisation. " What makes a drug stable is the absence of water" explains Dr Greer. "This is where the Materials Science comes in. How dry do they have to be to stifle molecular motion? How easy is it to get the water out and to put it back in without causing damage to the unstable drug? The answers to these questions need some rather tricky diffusion analysis, as the diffusion co-efficients for water-based glasses needed to be determined, and these vary, depending on the amount of water present.

Trinity College funded the research (on a 50:50 basis) as part of its policy for funding link projects between the Science Park and the University. Collaboration is continuing with Pafra, who are now in the position of being able to sell licences for their drug storage technique to pharmaceutical companies.

Further information from: Dr.A.L.Greer (01223) 334308

Editorial

We are excited by the continued development of new industrial research interactions; for example the Department has just been successful, in partnership with 17 UK materials companies and two other Universities, in landing two major Foresight Challenge Grants. In fact, they were the only two mainstream materials ones, of the 24 awarded out of 550 applications. One is in the area of turbine blade alloys, the other in polymers. Both strongly feature the development of computer based simulation methods to predict materials structures and properties. In this way they mark an important future trend in the subject.

The Department now has three embedded Industrial Units which include the Rolls Royce University Technical Centre, which blazed the trail. Our vision for the Department in the twenty hundreds includes a number of such embedded companies, carefully selected and forming an integral component of our activity. Research and teaching alike will benefit from being even closer to the commercial cutting edge. It will be a very far cry from Ivory Towers.

Contents

On The Right Track

Sections of the new bainitic rail

Many members of the department over the years have shown a fascination with bainite and with phase transformations in general. The painstaking studies conducted in this area are now bearing fruit, as demonstrated by some recent collaborative work with British Steel. As a result of a colloquium presented at the Swinden Laboratories on the subject of "Bainite", the department was challenged to come up with a design for rail steels. Conventional rail steels are basically pearlitic and rely on the presence of hard cementite for wear resistance. However, cementite is also rather brittle so that such rail steels lack toughness. Toughness is a useful property for rail steels, not only for resistance to gross fracture, but also in influencing the wear behaviour.

Using the theory developed for phase transformations in steels, it was possible in a very short time to computer-design three alloys without doing any experimental work. The alloys were configured to have a radically different carbide-free bainitic microstructure.

They were made and tested at British Steel, and found to exhibit exceptionally good wear and toughness properties. Experimental measurements confirmed the alloy design procedure and industrial scientists rapidly translated the concepts into a steel which could be produced in bulk and in available processing plant. These new types of rail steels represent a sizeable export market for British Steel; the track is currently undergoing trials in Switzerland, USA and Germany and preparations are being made for full-scale marketing.

The steels produced are basically low carbon, carbide-free, bainitic steels. The hardness is achieved by the fine grain size, rather than with cementite. The steels, which contain common alloying additions, are cheap to produce; it is only the microstructure which is different in the context of rails. Moreover the hardness is uniform throughout the rail cross-section.

Computer modelling as a means of designing new steels is now a very powerful tool. British Steel certainly have great confidence in this work, and currently are sponsoring several projects in this area in the Department.

Enquiries to: Dr Harry Bhadeshia T:(01223) 334301

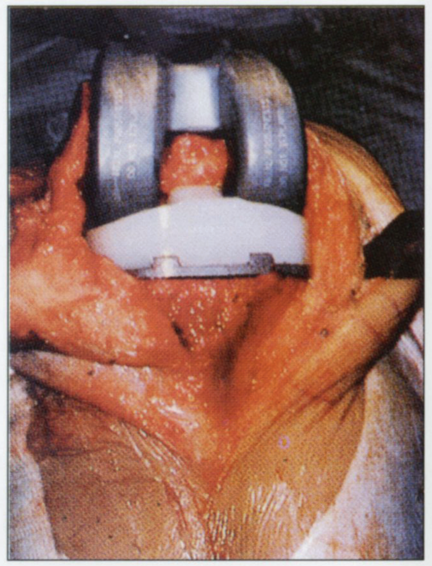
If you have any alterations to your address, or comments on this Issue please send them to the address below:

Mrs JulieTrim
Department of Materials Science & Metallurgy
Pembroke Street
Cambridge
CB2 30Z
http:/lwww.msm.cam.ac.uk/
Tel/Fax (01223) 334479
email JT215@cam.ac.uk

Joint Project

Each year, about one million patients worldwide have a total joint replacement. In the U.K. alone, some 40, 000 patients receive hip replacements and 18,000 knee replacements.

In current orthopaedic practice, ultra-high molecular weight polyethylene (UHMWPE) is used as one of the bearing surfaces. Although this material can function satisfactorily for 15 years or more if the joint is well designed and well implanted, debris from the articulating surface is of major concern, since it can induce adverse cellular reactions, bone-resorption or osteolysis, resulting in joint loosening. This then necessitates undesirable revision operations.



A knee joint prosthesis during implantation showing the metallic component which has replaced the femoral condyles articulating against the UHMWPE plateaux. The femoral component is on the top and the tibial bearing surface is underneath.

In contrast to the highly conforming ball and socket joint of the hip, the knee is a hinge-type joint, with concentrated contact between the tibial and femoral components. This results in high contact stresses, close to the yield stress of the UHMWPE. The maximum stress occurs beneath the polymer surface.

UHMWPE is a semi-crystalline polymer and deformation occurs in both the amorphous and crystalline components. Under normal conditions of crystallisation, UHMWPE has an orthorhombic crystal structure. During deformation in an artificial knee joint, the polymer crystallites become oriented and may also undergo local martensitic transformations to the monoclinic phase. These phenomena are being studied in a research project within the Department's Tribology Group by Munna Choudhury, under the supervision of Dr. Ian Hutchings.

Gamma irradiation, a process routinely used to sterilise the prostheses after manufacture, causes the polymer to become reactive and undergo subsequent oxidative degradation and property changes. Chain scission occurs as well as molecular cross-linking; oxygen from the atmosphere also plays a key role. Significant changes occur in the structure and mechanical properties. These include an increase in crystallinity which results in partial loss of ductility of the material.

The effects of irradiation dose and post-irradiation ageing on the molecular structure and mechanical and tribological properties of UHMWPE are also being studied. In particular, the wear of the polymer has been explored after different treatments. Gamma irradiation, followed by ageing, has an adverse effect on wear resistance.

Thus polymer components which have been stored for a long time before implantation may undergo premature failure. This is a cause for serious concern, and a major reason behind this project, which is sponsored by Howmedica International, a division of Pfizer Hospital Products.

For further information, please contact Dr Ian Hutchings T:(01223 334368).

No longer 'men only'

Students gaining 'hands-on' experience in the Class Laboratories

Following the first issue of Material Eyes, we received a number of letters, including one from the first female to graduate from the Department, Mrs. M.D. Eborall (nee Smith, 1938-41, Girton). Along with several other correspondents, she expressed a desire to know more about the current structure of the undergraduate teaching course, the male /female ratio, and the further careers of graduates from the Department.

One of the biggest changes in recent years is about to happen: the introduction of a new four year course, in October 1997. Further information concerning this will be given in a future issue. The largest change in male/ female ratio occurred in the mid-seventies when many of the colleges went mixed. The numbers of females taking the Part II class rose from one or two per year, to roughly one third of the Part II class which usually numbers approximately thirty.

Dr. John Leake, Deputy Head of the Department, keeps track of the many students who have passed through the Department since he was first appointed to the academic staff in 1968. Roughly half of the class goes on to further higher education, as it is known," he comments. "Of that group, a significant proportion go on into industrial work as professional Materials Scientists or Metallurgists after completing a Ph.D. Of those who leave after completing a first degree, some go into industry, whereas the others are spread over a diverse range of professions, including law (particularly relating to intellectual property) and finance." There does seem to be a high demand from other Universities for our post-doctoral students. For instance, within the last year, ten researchers from the Department have been appointed to lectureships in other British Universities (including a significant number of women).

At its inception, the Department was known as the Department of Metallurgy. Materials Science was first introduced as a Part II option in 1965/ 66. It became a combined course with Metallurgy in 1975/76 and the course name of Materials Science and Metallurgy was introduced in 1986/ 87. It is interesting to see that the plans for moving the department to a site in West Cambridge simply refer to it as the Department of Materials Science. Is Metallurgy about to become a forgotten subject?

Many thanks to all those who took the trouble to write to us and we look forward to receiving more news and views in the future.

Enquiries to Dr. John Leake, T: (01223) 334331

New Chair in Materials Chemistry

Professor Derek Fray

Derek Fray was appointed the Professor of Materials Chemistry at the Department in February 1996. As a former lecturer (1971-91) he will be known to many alumni. The Chair in Materials Chemistry is a new one, to cover a need in an area that has been to some extent neglected over the last few years.

"Most departments have concentrated on the physical properties of materials" explains Professor Fray. "There is still a need for materials chemists and this is an area not being sufficiently well covered in other universities." With specialisations including sensor technology, clean technology and waste minimisation, highlighted in the recent technology foresight exercise, the expertise that Professor Fray brings to the Department is sure to be in great demand. "Another opportunity for Universities is that with industry concentrating more and more on short term problems with many laboratories being closed, Universities are becoming the only places where medium and long term research can be carried out. In fact, one can foresee Universities becoming the sole initiators of novel ideas in many of the traditional extractive industries. There is also a considerable need to produce graduates and post-doctoral researchers with an innovative approach to problem solving."

Derek Fray began his career with a Royal Scholarship to Imperial College, London, where he studied Metallurgy. He continued his research at Imperial until 1965 when he was appointed Assistant Professor at MIT, before returning to the UK in 1968 to work in the Research Department of the Imperial Smelting Corporation, working with fused salt electrolysis, processing of zinc dusts and residues and the refining of alloys containing aluminium. Following his time at Cambridge from 1971-91, he was appointed Professor of Mineral Engineering at Leeds University where he became Head of Department of Mining and Mineral Engineering in October 1991.

A fellow of Fitzwilliam College, Cambridge, Derek has published over 180 articles on materials processing, one book and is now being cited as inventor on 33 patents. His awards include the Sir George Beilby Medal of the Royal Society of Chemistry, (1981), the Kroll medal of the Institute of Metals (1987) and the John Phillips Medal from the Mineral Industry Research Organisation (1991). He consults widely on the use of solid electrolyte sensors, applications of fused salts, electrowinning from aqueous solutions and the recycling of metals.

With his wife and two grown-up children, Professor Fray is looking forward to the challenge that his return to Cambridge will bring, and not least the opportunity of renewing his interest in sailing off the East Coast. He is warmly welcomed back, along with the team of post-doctoral researchers who will be following him from Leeds. It is hoped to feature some of these areas of research in more detail in future issues of Material Eyes.

The copy was written by Sue Jackson, produced by Julie Trim and printed by Elitian Limited, Mill Road, Cambridge

Congratulations to

- Dr Zoe Barber on her appointment as Snr. Technical Officer in the Device Materials Group.
- Dr Harry Bhadeshia on being awarded a Leverhulme Trust Senior Research Fellowship by the Royal Society, for one year commencing October 1996.
- Professor Robert Cahn for 3 honours: one, the Heyn (platinum) medal for 1996 awarded by the Deutsche Gesellschaft fur Materialkunde E.V., its premier award, the second his election as a foreign member of the Spanish Royal Academy of Exact Sciences in Madrid, and in July he was elected as a foreign member of the Chinese Academy of Science.
- Professor Sir Alan Cottrell on being awarded the Honorary Degree of Doctor of Law by the University.
- Dr Hidetoshi Fujii on his appointment to the position of Associate Professor at Osaka University, Japan.
- Dr Lindsay Greer on his promotion to Reader in Microstructural Kinetics from 1.10.96.
- Dr Simon Howard on his award of a joint Defence Research Agency/Cambridge fellowship
- Professor Colin Humphreys for his election to the Royal Academy of Engineering and for the Elegant Work Prize of The Institute of Materials achieved jointly with Dr Paul Brown.
- Dr Ian Hutchings for his award of a Cambridge Foundation (Pilkington) Prize for his excellence in teaching.
- Professor Kelly on his appointment as President of the Institute of Materials for 1996-97.
- Mr Keith Rutherford and Milo Schaffer on winning an Institute of Materials Lecture Prize.