

## Editorial

The big event coming up next year is of course Carbon 2006 at Aberdeen in July. We are delighted to be hosting this prestigious international meeting and are sure that it will have the same success as Carbon 96 did at Newcastle, 10 years ago. Much of this issue is taken up by information about this conference but there are also reports on other significant meetings over the past year.

At the other meetings in this series, held in various countries, a considerable proportion of the delegates are from what one might call the “home team” and your committee hopes that there will be a very good turnout from the UK and Ireland. The ancillary programme looks very attractive, with a reception in the City’s Art Gallery, a ceilidh, whisky tasting and much more (as they say). As Prof. Bob Bradley pointed out when the proposal was first mooted, this will be the first Scottish international carbon conference and this aspect has no doubt been an attraction for potential foreign attendees. We have had an excellent response to the call for abstracts and these cover the whole range of carbon research and technology in a very comprehensive manner. Those who have supported the very lively and scientifically outstanding **NanoteC** conferences over the years should note that **NanoteC06** is being held within the framework of Carbon 2006, rather than at its more usual place in the calendar. Several awards, some of them for the first time, will be made at the meeting during which we also intend to hold the Group AGM, so the minutes of the 2005 AGM are included here. Please make a special note of the week of July 16-21<sup>st</sup>.

We have had three very successful meetings over the past 10 months, starting with the Spring meeting in Brighton. Like many other Groups, we have had problems with attracting support for our smaller meetings, so it is good to report that this one was very well-attended and fully justified the high level of its scientific content. This was true also for **NanoteC05** in Brighton in August and the meeting of Ageing Management of Nuclear Reactors in Cardiff in November, both of which were very successful in all respects.

Chris Ewels has contributed an interesting article on potential health hazards of carbon nanoparticles. As I write this, I am watching a very large plume of carbon microparticles “Toxic cloud” according to the London “Times”—what do they know that I don’t?) travelling to the north of me fortunately, deriving from the enormous fire at the Buncefield oil depot only a mile away, so I have a vested interest in this topic (has anyone thought of analysing this plume for fullerenes?).

I’m also grateful for an article that reviews very comprehensively Turkish activity in carbon nanotechnology, obtained through Tony Wickham’s good offices.

Finally, I am glad to welcome back our SCI members. We have at long last managed to sort out with the SCI the difficulties about collecting subscriptions and it looks as though a new era of co-operation has begun.

Norman Parkyns

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## Carbon 2006

As I hope you will all now realise, the BCG is hosting this conference in Aberdeen from July 16-21<sup>st</sup>. It will be based at the Robert Gordon University in the city centre and block accommodation has been reserved. All the details including registration form are available at the website [www.carbon2006.org](http://www.carbon2006.org) so there is no need to go into great detail here but a few comments about the main features will come amiss. The important thing to note here is that registration forms can be accepted from now on by mail, fax or e-mail.

The deadline for preliminary abstracts has now passed and the Programme Committee has received nearly 700 (no I see from Tony's account that I'm out of date already-it's nearer 800), so they have the headache of how to sort and select from this excellent response. The University have been very co-operative about the venue, so the main plenary lectures will take place in the MacRobert Hall: immediately outside this will be a very splendid marquee, where most of the ancillary events, including poster sessions, coffee and a ceilidh with whisky tasting on the Monday evening will take place.

Tony Wickham, the official conference organiser has provided below a lively account of what's on offer, so your Editor will close his modest contribution and let Tony's have full sway.

### Carbon 2006—the Full Monty!

Finally, after years of planning and the eventual selection of Aberdeen for the 2006 International Carbon Conference, *it's this year!!*

Suddenly, July 16<sup>th</sup> seems awfully close. Although Sunday 16<sup>th</sup> is the official start of Carbon 2006, there is a Summer School on 'Nanoporous Carbon Adsorbents' which starts on the previous Thursday morning, so we shall be taking over Aberdeen for the best part of ten days. We also include **NanoteC06** within the conference, drawing upon the success of recent events held at Sussex University and in France.

A huge amount of preparation has been made by the Organising Committee, with Tony Wickham at the helm again as Conference Manager and Bob Bradley of the Robert Gordon University as the local host. The Programme Committee, headed by Mark Thomas with Gareth Neighbour as deputy, is currently addressing the near 800 – *yes, that's near 800* – abstract submissions involving more than 450 individual submitting authors. Carbon 2006 is going to be **big** and Aberdeen is definitely the place to be in July if you are in any way involved in any aspect of carbon science.

Obviously you are, or you would not be reading this, so you should head quickly to the excellent conference website [www.carbon2006.org](http://www.carbon2006.org) where you will find extensive information on all aspects of the conference including the Plenary speakers, a special introductory address from (Professor Sir) Harry Kroto, social events (*spooky castle, City Art Gallery, conference dinner*), the accompanying persons' tour programme, the

dinner.... all the usual stuff and, as we are in Scotland, let's add the ceilidh (from a group called 'SpöЯRan' Again, would you believe<sup>1</sup>) and the whisky tasting.....

... .. but the most important aspect of the conference remains its scientific excellence, something which has never been in doubt since Prof. Ubbelohde first founded carbon conferences at Imperial College in the sixties. So it is worth saying again, *Aberdeen is the place to be this coming July*. The website offers full information on the range of accommodation options in hotels, B&B's (*no doubt offering an Arbroath smokie as a breakfast option*) and inexpensive but rather fine University accommodation. It also provides the Registration Form – and BCG members, of course, can claim a discount on their fees. You can register and pay up right now – we are *not* taking fees directly on the internet for security reasons but you can certainly use Visa and Mastercard and can transmit your details to the registry by a method of your choice – you can book a hotel right now directly through the website at privilege rates – *the 'early bird' catches the best accommodation – don't delay!*

If there is anyone out there still living in the 'quill pen and ledger' era (as Tony Wickham sometimes claims *he* is) then he will provide full information in a suitable medium if you contact him on (*phone*) 01597 860633 (*fax*) 01597 860244 or the basic conference *e-mail* contacts which are [confer@globalnet.co.uk](mailto:confer@globalnet.co.uk) or [info@carbon2006.org](mailto:info@carbon2006.org). The conference registry 'snail mail' address is 'Carbon 2006', P.O. Box 50, Builth Wells, Powys LD2 3XA.

So let's have a huge turnout of our own members. Add on a family holiday - do we need to mention that the Grampian Highlands are nearby, you will be in Royal Deeside 'just down the road' from Balmoral, the golf courses are magic, even sandy beaches and secluded coves.....and it is a darn sight closer (and cheaper to reach) than Seoul was last year! There are particularly cheap flights to Aberdeen from Stanstead if you book early, and flights from many other UK airports. APEX travel on trains is cheap if booked well in advance and there are direct trains from London Kings Cross (GNER) and also from the west of England (Virgin Cross-Country). At worst you would need to change in Edinburgh or Glasgow.

Finally, there will be surprises. We have already discovered that within the confines of the City of Aberdeen it is absolutely forbidden to throw anything off a roof except snow, and when we take you to Crathes Castle for the evening it is *absolutely* not permitted for anyone to take along a deep-fat fryer. So just watch your step and you'll be fine. Other more useful surprises awaiting you are the bistros of the University locality, the fact that it is light until 11pm in July, and the overwhelming friendliness of the locals. Come and join us, and enjoy.

Tony Wickham

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<sup>1</sup> You'll only get this joke in full if you are an ABBA fan (*Björn Again.....?*) and it would be even simpler if I could get this computer to do a 'B' backwards.....

## **Brian Kelly award**

It is timely to remind all potential attendees to Carbon 2006 that papers will be eligible for entry for the Brian Kelly award. This was set up jointly by the American Carbon Society and the BCG to commemorate the life and work of Dr. Kelly who did seminal work in the field of graphite research, as well as being an Editor of the journal, Carbon. It will be to the value of about \$1000 but as the conference is being held in the UK, according to the terms of the award, it cannot be given this year for work carried out here. However, there may be members who are working overseas who may be eligible and any work from outside the UK will be potentially considered.

I will just repeat here the general conditions for consideration for an award. *“The award is intended as a travel grant for students or young researchers under the age of 35 to attend the annual international carbon conference. Anyone living or working, at the time of that conference, in the country where the conference is held is not eligible. As a consequence, applications will not be accepted from the UK on this occasion.*

*The award is made upon the basis of an appraisal of the extended abstract or paper submitted to the conference organisers, together with a short CV and commentary provided normally by the candidate’s supervisor or close colleague. However, self-nomination is permitted. A committee of British Carbon Group officers will choose the successful applicant”.*

Heads of department or senior research associates of potential nominees are invited to submit candidate names for the award, in the first place to Prof. Brian McEnaney, [B.McEnaney@bath.ac.uk](mailto:B.McEnaney@bath.ac.uk)

## **Prof. B. McEnaney**

As many of you will know, Brian McEnaney retired from his Chair in the Materials Science Department of the University of Bath last year, after many years service there. He has been active over this entire time in the field, among many others, of carbon research, from microporous carbons up to carbon fibres and cokes and has published many papers and received many honours for this work. In between this busy schedule, he has managed to find time to be a very active member of the British Carbon Group, including filling the Chair. It is with very great pleasure therefore that we hear that the University has granted him the title of Professor Emeritus as a mark of his standing in scientific research.

He has written a very timely account that appears later in this newsletter, of the series of international Carbon Conferences in Britain, in many of which he has taken part. It was of special interest to me as I was a research student of Prof. Ubbelohde’s in 1957 when the first London Graphite and Carbon Conference took place, although I was not working on carbon at that time and didn’t attend it. Research students had a much more stay-at-home existence in those far-off days. These days, I would have been conscripted into taking part in the more menial aspects of helping to run the show.

We are very glad that we can call on the very wide experience of Prof. McEnaney who, as you can see, will play a leading role in the organisation of Carbon 2006.

### **E-mail versus snail-mail?**

This newsletter represents the most tangible link between the Group and possibly, most of its members. Your committee has recognised this and over the years has tried to produce issues that are informative as well as entertaining. As Editor, when I look at our distribution list, I can see that although most of our members live and work in the British Isles, many do not and indeed, some work in far-flung corners of the globe, as the curious phrase has it.

Producing the hard copy that you are reading at the moment does require a certain amount of extra effort on my part in the sense of having the copies printed, stuffed into envelopes and then taken to the local post office, where each individual overseas copy outside Europe has to be weighed separately and stamped accordingly. I'm happy to do this: it's why the committee has put up with me for so long but it has occurred to me that in this IT-led age, some of you would actually prefer to have an electronic version sent to you direct. Personally, I like to have something in my hand that I can read where I like, in the train, in bed or wherever and a show of hands at a recent committee meeting suggested that this old-fashioned view still had majority support. However, if you would like just to have something to read off the screen, I'm happy to oblige. Simply e-mail me to that effect at [norman.parkyns@tesco.net.uk](mailto:norman.parkyns@tesco.net.uk) (in the UK you can leave out the .uk bit) and I'll put you on an e-mailing list and cease sending you printed copies.

### **Nanocarbon and nanodiamond 2006**

A conference on this topic is being organised at St. Petersburg, Russia for September 11-15<sup>th</sup>, 2006. It will concentrate on ultrananocrystalline diamond and nanocarbon onions and graphite, in the same way as earlier meetings on this topic. Details can be obtained by visiting the website <http://www.ioffe.ru/nanodiamond> or by e-mail to [Nanodiamond@mail.ioffe.ru](mailto:Nanodiamond@mail.ioffe.ru)

### **Conference Report: "Ageing Management of Graphite Reactor Cores"**

**University Hall Conference Centre, Cardiff, 28<sup>th</sup> – 30<sup>th</sup> November 2005**

If anyone needed evidence that the nuclear graphite business, if not its actual manufacture, continues to flourish in the UK, then the attendance of nearly 90 delegates at this three-day meeting should show that there are many universities and industrial concerns involved in monitoring the behaviour of nuclear graphite manufactured in the sixties and seventies which remains 'hard at work' as a structural material and nuclear moderator in the Advanced Gas-Cooled Reactors and the remaining Magnox reactors whilst subject to intense bombardment by energetic neutrons and to oxidation initiated by

the interaction of ionising radiations with the largely carbon-dioxide coolants used to transfer heat to generate electrical power.

This conference was initially proposed by The Health and Safety Executive's Nuclear Safety Directorate to involve not only the power-station operating organisations and their technical staff but also their contractors and specialist advisers, to encourage the widest possible interchange of views and experience in order to underwrite the understanding of graphite irradiation behaviour, not only in the basic material but also in the complex core components made from it and in the entire 'stacks' of graphite blocks which form the fuel channels in the heart of reactors.

Generous additional sponsorship from British Energy, The British Nuclear Group, Nexia Solutions and Serco Assurance, added to that from the HSE which also supplied the services of Tony Wickham's conference management team, ensured that the registration fees could be kept low. Following an introductory session on the first afternoon in which each of the principal reactor operators discussed their graphite-core safety-case strategy and the supporting research, the HSE gave their own perspective on the vital role of the Nuclear Installations Inspectorate and its approach to such safety cases. Subsequent sessions explored the basic reactor physics of the graphite irradiation, the behaviour of large graphite components, especially in regard to the build-up of stresses and the potential for cracking, and finally the behaviour of whole cores. A final session saw independent views from Prof. Brian Eyre, formerly the head of AEA Technology, and Prof. Michael Burdekin, formerly of UMIST.

The Proceedings will be published in full in hardback in the Spring by one of our three sponsoring bodies, The Royal Society of Chemistry. Gareth Neighbour from The University of Hull will edit the publication: meanwhile CDs of all presentations are available from Tony Wickham.

In addition to the operating companies, the sponsoring organisations and numerous contractors, seven University departments were represented (Bath, Birmingham, Hull, Leeds, Strathclyde, Sussex and a particularly large contingent from Manchester) and delegates also attended from the US Nuclear Regulatory Commission, NRG Petten in The Netherlands, Graftech International in Ohio and the PBMR Company in South Africa which is developing a new generation of reactors using graphite as a reflector material.

We also managed to fit in an excellent informal conference dinner at The Waterguard in Cardiff Bay. All in all, another success for the British Carbon Group keeping its finger on the pulse of all branches of carbon science in the UK.

## The International Carbon Conferences in Britain

Nowadays, international carbon conferences roll off a production line somewhere in the world each year....2003, Oviedo, Spain; 2004, Providence, USA; 2005, Gyeongju, S. Korea; 2006, Aberdeen, Scotland; 2007, Seattle, USA; ... 'Carbon 2006' will be the first of the full-scale international carbon conferences to be held in Scotland, although it will be the ninth one to be held in the UK. So where did all these carbon conferences start?

The first carbon conference was held in the USA in 1953 at Buffalo, New York State. The meeting was organised by Professor Mrozowski of the University of Buffalo. It was a small beginning since only 4 papers were presented. Professor Mrozowski organised further conferences in 1955 and 1957, so establishing the biennial frequency of American Carbon Conferences that persisted into the 21st century. The first British Carbon Conference was held in London on 24-26<sup>th</sup> September 1957 in the same year as the 3<sup>rd</sup> American Carbon Conference but on different dates. The Proceedings published after the Conference in 1958 contain 68 full papers and records of discussions. There were many notable contributors to the first proceedings, including the leading American carbon specialists Professors Mrozowski and Walker. William Watt FRS of the Royal Aircraft Establishment at Farnborough presented a paper with ARG Brown on pyrolytic carbon. Watt later made major contributions to the development of PAN-based carbon fibres for which he was made a Fellow of the Royal Society.

Rosalind Franklin with another Watt (JD) presented a paper on the structure of carbons after gaseous oxidation. Franklin's earlier work on the structure of graphitising and non-graphitising carbons *e.g.*, *Acta Cryst.*, 1950, **3**, 107. *Proc Roy Soc.* 1951 (A) **209**, 196, is well-known and is still cited. However, she is more widely known for her crucial role in the elucidation of the structure of DNA, a contribution that was perhaps insufficiently recognised at the time. The famous Russian scientist MM Dubinin presented one of the earliest reviews in English of his work on the porous structure and adsorptive properties of active carbons. His paper did a lot to promote in the West the use of his isotherm equations for adsorption of gases and vapours on porous carbons. I must also mention a paper presented at the first conference from King's College, Newcastle upon Tyne, by Harry Marsh, with Harry Harker and Professor WFK Wynne-Jones, on the carbon-carbon dioxide reaction. Harry Marsh, of course, went on to become one of the most influential of British carbon scientists for the remainder of the 20<sup>th</sup> century and is still active in the 21<sup>st</sup> century. (In the 1950s King's College was part of the University of Durham, but, in an early example of velvet divorces, the College seceded in the 1960s to become the University of Newcastle upon a Tyne.)

One of the most influential scientists in the early days of the British carbon conferences was Professor AR Ubbelohde FRS of Imperial College. His presence was first recorded in the proceedings of the 2<sup>nd</sup> meeting in 1965 when he gave the introductory paper. Professor Ubbelohde played a leading role in the organisation of the early British carbon conferences and in the creation of the British Carbon groups in the 1960s. At first, there were two groups under the auspices of the Institute of Physics and the Society for Chemical Industry and Professor Ubbelohde was simultaneously chairman of both

groups. Professor Ubbelohde's genial and patrician presence was a feature of the British carbon conferences until the 1980s.

It would be tedious to go through the remaining eight British conferences and their proceedings in the same detail. The bare facts are summarised in the Table.

### **British Carbon Conferences 1957- 2006**

<b>No</b>	<b>Year</b>	<b>Venue</b>
1 <sup>st</sup>	1957	London
2 <sup>nd</sup>	1965	London
3 <sup>rd</sup>	1970	London
4 <sup>th</sup>	1974	London
5 <sup>th</sup>	1978	London
6 <sup>th</sup>	1982	London
7 <sup>th</sup>	1988	Newcastle upon Tyne
8 <sup>th</sup>	1996	Newcastle upon Tyne
9 <sup>th</sup>	2006	Aberdeen

The evolution of conference names is interesting. In the early days formal titles were used. For example, the 1965 meeting was 'The 2<sup>nd</sup> Conference on Industrial Carbon and Graphite'. Over the years snappier titles were introduced of which 'Carbon 19xx' and 'Carbon 20xx' are the most popular. In a spirit of European confraternity, some of the European meetings were called 'Eurocarbon 19xx', while the meeting held in Berlin in 2000 was rather grandly titled 'The 1<sup>st</sup> World Conference on Carbon'.

As the table shows, Aberdeen will be only the third venue for the British carbon conference. Previous conferences were held either at Imperial College, London, or at the University of Newcastle upon Tyne. The Robert Gordon University at Aberdeen was chosen after a beauty contest in which five UK Universities bid for the chance to host the Conference. The selection process bore some resemblances to the procedure for selecting host cities for the Olympic Games. A panel (well, a duo actually) was charged with visiting each site and preparing a factual report for the British Carbon Group committee to consider. At the crucial committee meeting, representatives of the bidders made presentations that emphasised the virtues of their fair cities and universities as conference venues before the committee made its choice.

From 1970 to 1982 the British meetings settled into a 4-year cycle that involved alternating an American Conference in 'odd' years with a European meeting in 'even' years. Initially, European meant Britain or Germany. The cycle length increased to 6 years (1982-88) with addition of France in 1984 and then to 8 years (1988-96) with the addition of Spain in 1994 and then to 10 years (1996-2006) when the current triennial cycle involving the USA, Europe and Asia-Pacific was started in 2002. An increasing number of countries now wish to bid to host the international carbon conferences, so, if this trend continues as it surely will, it seems that after 2006 the British Carbon Conferences will appear at about the same frequency as Halley's Comet. Given this



trend, we must seize this opportunity and ensure that 'Carbon 2006', which will take place close to 50 years after the 1<sup>st</sup> British Carbon Conference, will be as great a success as its eight predecessors.

Brian McEnaney, University of Bath., 8 July 2005

## THE BRITISH CARBON GROUP

MINUTES OF THE 2005 ANNUAL GENERAL MEETING HELD AT THE UNIVERSITY OF SUSSEX AT BRIGHTON ON, 2<sup>nd</sup>. SEPTEMBER, 2005 AT 6.00 pm

PRESENT: Professor M.I. Heggie (Chairman), Dr. C.J. Hindmarsh (Honorary Treasurer), Dr. J. Fisher (Honorary Secretary), 5 committee members: Professor S. Mikhalovsky , Dr. A.J. Wickham, Dr. P. Minshall, Dr. C.P. Ewels, Dr. N. Grobert, plus 17 members.

### APOLOGIES FOR ABSENCE:

Apologies for absence were received from:

Professor J. W. Patrick, Dr. N. Parkyns, Dr. A.V.K. Westwood, Dr. J. Goss

### MINUTES OF THE PREVIOUS MEETING

The minutes of the previous AGM, held on the 30th August, 2004 at the IOP, London were approved as a true record, with one error corrected.

### ACTIONS AND MATTERS ARISING (not covered in Agenda)

There were no matters arising.

### CHAIRMAN'S REPORT (Professor M.I. Heggie)

From AGM 2004 to the AGM 2005.

The period since the last AGM, held following the workshop on 'Foresight Carbon' has again been a busy time for the BCG.

The "2005 year" began early in October 2004 with the BCG supported "*Advances in Carbon Electronics 3*", a one day conference organised in London by the Institute of Electrical Engineers.

Later in October 2004 the **NanoteC04** conference was held in Batz-sur-Mer, France. Although organised primarily by GFEC, there was a strong input from the BCG. It proved to be the largest **NanoteC** to date, with 165 participants.

In March 2005 a two day conference and workshop, “*Carbon Materials: Science and Art*”, was organised by the BCG (Professor Sergey Mikhailovsky) at the School of Pharmacy and Biomolecular Sciences, University of Brighton. It was a rather successful moderately sized conference with a distinctive international flavour – speakers from UK, Ukraine and US.

In 2005 the **NanoteC05** annual conference returned to its traditional home, Brighton, organised again by the British Carbon Group. This meeting was again well supported and successful, being truly international with 90 participants, from the UK as well as Turkey, Syria, Israel, Russia, Taiwan, Japan, South Africa and several European countries. Congratulations for this success go to my co-organisers, Drs Chris Ewels, Nicole Grobert and Greg Van Lier, as well as the conference manager, Dr. Tony Wickham.

This AGM is being held during **NanoteC05** and the good attendance has demonstrated the benefits of holding the meeting during a “major event”.

Later in the year (28th - 30th November 2005) a 3-day specialist meeting entitled “Ageing Management of Graphite Cores of Gas-Cooled Reactors” is being organised by the BCG at the University of Bath. HSE/British Energy/BNFL are sponsoring the meeting

Much of the BCG committee’s efforts this year have again been directed to organising the international carbon conference to be held at the Robert Gordon University in the city of Aberdeen in July 2006. This C2006 will be preceded by a summer school on ‘Nanoporous Carbon Adsorbents: The Key to High Performance Filtration’ and Porosity.

**NanoteC06** will also be held in Aberdeen during the C2006 annual conference.

Professor Heggie expressed his thanks to the officers and committee of the BCG for their efforts during 2004 /2005, recognising the professional but voluntary nature of their input. In particular he thanked the two retiring committee members, Dr. Norman Parkyns and Dr. Chris Ewels.

## TREASURER’S REPORT

Presented by Dr. C.J. Hindmarsh.

### Election of officers and Committee members

At this the 2005 AGM the Chairman and Vice Chairman had to offer themselves for re-election.

In addition Dr. N. Parkyns and Dr. C. Ewels have to retire and are not eligible for re-election for the next year.

The following officers and committee members were elected unopposed.

Officers:

Chairman: Professor M.I. Heggie (University of Sussex)  
Vice Chairman: Professor J.W. Patrick (University of Nottingham)

Committee Members:

Professor K.M.Thomas University of Newcastle  
Dr. G. Neighbour University of Hull

The following were notified as representatives of the sponsoring bodies:

SCI representative Professor R.H. Bradley (Robert Gordon  
University)  
RSC representative Dr. A.J. Wickham  
IOP representative Dr. J. Goss (University of Newcastle)

The following have been co-opted onto the committee of the BCG.

Dr. N. Parkyn - Newspaper Editor  
Dr. C. Ewels - "BCG Webmaster"  
Professor B. McEnaney - Carbon 2006 organising committee

Any Other Business

There being no other business previously notified the meeting was closed at 18.45.

**A spoonful of Graphite : Carbon nanoscience and public health**

Less than fifty years ago, every child in France would start the day with a spoonful of – not cod liver oil, or some vitamin cocktail – but graphite. Whether they wanted it or not, it was deemed important ‘for the good of their health’ (and heavily sugared to help the medicine go down, so I’ve been told). It seems that carbon and public health are two issues that have never been that far apart, perhaps not surprisingly given our reliance on carbon based materials and the ubiquitous nature of carbon, down to the building blocks of life itself.

Carbon and health issues have recently reappeared on the radar with the upsurge of new carbon based nanotechnology. A range of new carbon based materials are under development in the laboratory, including notably fullerenes and carbon nanotubes, and these are now poised to break into the commercial marketplace in a number of new products. As production costs come down and technological control of these materials improves they are expected to become an important component in an ever increasing

number of real-world applications. For this reason it is unsurprising that there is great interest in any possible health implications associated with these new materials.

Rather than adopt a 'head in the sand' approach, the nanoscience field is tackling these questions head-on. It is arguably the first new scientific field to so publicly adopt such an approach. Significant fractions of US and European nanotechnology research budgets have been earmarked for toxicity studies of new nanomaterials<sup>2</sup>, and there have been many recent high profile reports on potential social and public health implications of nanotechnology, notably the Royal Society / Royal Academy of Engineering Report on nanotechnology published in 2004<sup>3</sup>.

It is important not to confuse concern with paranoia. It is the responsibility of the scientific community to ensure that any new science emerging from our laboratories has undergone thorough safety testing and risk analysis. The public (including scientists in that term) have a right to such an assurance, and in the long run public support for new scientific inventions is essential if they are to become widely accepted and exploited. GM foods provide a good example of what happens when such trust breaks down. It is best to tackle these questions at the earliest possible stages. In this way our understanding of the public health implications becomes an integrated part of the knowledge and decision making surrounding nanomaterials, rather than a hastily tacked on addition once all the dust has settled.

Equally any toxicity studies of nanomaterials should not be considered an exercise to 'convince' the public of the safety of nanomaterials. Questions concerning toxicity of nanomaterials are genuine scientific questions that should be examined, proved, or disproved, using rigorous scientific methodology.

Perhaps strangely, many groups working to resolve exactly these questions have run into an unexpected problem. Toxicity studies of nanomaterials are strongly cross-disciplinary, requiring both a detailed knowledge of biological testing techniques and at the same time the skills necessary to synthesise, purify and separate the nanomaterials. This peculiar mix of biology, chemistry and physics means that the resultant work is hard to classify, and falls outside the remit of most conventional journals. A colleague of mine working in this field recently had an article rejected from five different journals, never on its scientific content but always because its content was outside the scope of that publication.

For this reason the scientific journal 'Carbon' should be applauded for its recent decision to devote a whole issue to the question of toxicity of carbon nanoparticles (due out early in 2006). This provides a much needed outlet for a range of work which is both timely and important for the public debate.

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<sup>2</sup> US spending was \$8.5 million in 2004, rising to \$38.5 million in 2006 on environmental and health implications of nanotechnology. There have been calls to raise this to \$100 million. The RS/RAE Nanotechnology report called for £5-6 million per year for 10 years for development of methods and instrumentation for nanomaterial testing.

<sup>3</sup> <http://www.nanotec.org.uk/finalReport.htm>

For the record, the majority of scientific studies to date seem to be showing that carbon nanomaterials are not toxic to human health. Recent studies at Rice University found that waterborne carbon nanotubes were only cytotoxic at high doses of 200 parts per billion, ten times less toxic than carbon fullerenes which themselves appear to be extremely low risk. Sulphite or carboxylic acid functionalised carbon nanotubes were non-cytotoxic in their studies. There have been causes for concern in other studies, notably more complex functionalised nanotubes have been shown to penetrate cell membranes. The toxicity or otherwise of increasingly complex attached functional groups is an area deserving further study, and there is a need for more in-situ toxicity studies to better understand how the body processes and eventually expels nanomaterials. Just because these early studies seem in general to be reassuring, this is no cause for complacency, and toxicity studies of these materials will continue.

Meanwhile, the 'Carbon' journal has mooted the idea of a possible future issue dedicated to beneficial health aspects of carbon science – a spoonful of graphite, anyone?

Chris Ewels

## **NANOTECHNOLOGY IN TURKEY**

Ahu Gümrah Dumanli and Yuda Yürüm

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Nanotechnology has become a strategically important research and application facility that can be even used as an indicator to show the level of development of a country. Although nature has been using nanomaterials for millions of years, human beings could be able to use nanotechnology for their benefits only recently. Technologically useful properties of nanomaterials are not limited to their chemical, structural or mechanical behaviors; their interfacial layers and quantum energetics due to their small size combining with the exceptional optical and electronic properties are also taking the of interest of many researchers and it is expected that nanomaterials would be the ground breaking improvement in the scientific areas such as pharmacy, information

storage, chemical and optical computers, metals, ceramics, polymers, catalysts, sensors, batteries etc.<sup>1</sup>

In Turkey, the most of the nanotechnology research have been theoretical and stayed in individual basis. On the other hand, with the courtesy of 6<sup>th</sup> Framework of European Union, the nanotechnology researches are starting to reconstruct and gain another perspective. The first nanotechnology conference was organized by Bilkent University in Ankara in the year 2005. The interest to this conference was great and the amount of participants was more than expected with high quality of scientific studies.

Both state and private universities are starting to dedicate budgets for nanotechnology research, and government and private foundations initiated to support nanotechnology research. Additionally, Turkey has participated in the 6<sup>th</sup> Frame Programme of European Union and proposals related to nanotechnology and nanoscience have already being supported by the Programme. Under this frame, a National Nanotechnology Research Center was established by the contribution of Bilkent University and Turkish State Planning organization.<sup>2</sup> Nanotechnology Research Center at Bilkent University is dedicated to research on theoretical and experimental nanoscience and nanotechnology with strong emphasis on education and training. Interest areas of this research center are focused on both theoretical work such as the main problems of nanoscience and application of nanotechnology in the form of nanotubes, nanowires, quantum dots, magnetic molecules, frictionless surfaces. Center is an inter-disciplinary research environment which houses the nanotechnology related research efforts in science and engineering faculties, and serves to all departments in both faculties as well as the other Turkish universities that would like to have access to the center's facilities.<sup>3</sup> As a sharing information facility, the 7<sup>th</sup> National Optics, Electro-optics and Photonics workshop will be held by Bilkent University on 12 Dec 2005 also.<sup>4</sup>

Other Turkish universities, which are trying to compete in the international research arena, are forming their own nanotechnology research and development centers, conducting their nanotechnology researches mainly focused on the advanced ceramics, nanostructured thin films, semiconductors, nanocomposites and advanced polymers.

Sabancı University in Istanbul, which is a private university, is one of the pioneering universities in the nanotechnology research area with the coordinative work of programs of chemistry, materials science and engineering, microelectronic engineering and bioengineering which has produced quality works on nanoporous and nanoscale carbon materials, gels and sensor technology, ceramics, optical materials, liquid crystals and nonlinear optic polymers, functional and conductive polymers, processing of nanocomposites and computational modeling studies.<sup>5,6</sup> The 6<sup>th</sup> National Optics, Electro-optics and Photonics workshop had been realized by Sabancı University on 10 Dec 2004, additionally the workshop entitled “EU 6<sup>th</sup> Frame Information Day about Nanotechnology and Nanoscience” was conducted in Sabancı University also.<sup>7</sup>

Another private university, Koç University in Istanbul has a Micro-Nano Technologies Research Center and mainly focused on the micromechanical device fabrication, solid state laser materials, electromagnetic actuators, super hydrophobic surfaces as well as thin films of organic materials, surface modification by chemical and physical methods, characterization of nano-structured materials, friction at the atomic scale and nano-rheology of liquids and polymers and synthesis advanced polymers.<sup>8</sup>

The nanotechnology research is not a new subject for the well known state universities namely Middle East Technical University and Hacettepe University in Ankara and Bosphorus University in Istanbul. There is a Central Laboratory and R&D Center in METU and the nanotechnology research is mainly focused on biomaterials, intelligent materials and nanocomposites. Hacettepe University with its Departments of Chemistry and Chemical Engineering have been contributing to the fields of nanopolymers, nanocomposites and nano-biomaterials for many years with active research groups working in these fields. Bosphorus University is contributing in the nanoscience and nanotechnology field internationally with its Nanotechnology and Smart Materials Advanced Technologies Research and Development Center. Other than universities there are high technology institutes such as Gebze Institute of Technology, MAM- Marmara Research Center which is the research center of The Scientific and Technological Research Council of Turkey and Izmir Institute of Technology are highly productive in the nanotechnology research area.<sup>9</sup>

All of the mentioned universities and research centers have the international research standards and they have high quality article outcome as a result of those research facilities.

The underlined workshops and universities are not one of their kind examples; there are many Anatolian universities which are dealing with the nanotechnology subject especially on advanced ceramics, ceramic-metal composites, surface modification, semiconductors, coatings, optical and magnetic properties.<sup>9</sup>

If one is dealing with nanotechnology, other than scientific improvement, there should be an industrially useful outcome of the research. Thus, other than universities, industrial companies are making their own progression by the R&D facilities also. One of the most important studies which take the interest of the public were the boron studies; Nanotechnology-NNT Company produces MCDP crystallites of boron and adds to the motor oil, this suspended boron nano particles coats the inner sidewalls of the motors of the automobiles which improves friction resistance and extends the motor life. Another important product is produced by a dye company, DYO-Nano a wall paint which is resistive to paling and getting dirty and has the property of self cleaning. As a result of the nanotechnological researches about polymer and surface modification, Arçelik Company, which is a white goods and electronics company, has marketed two products; first one is odor filtering hygienic refrigerator and the second one full protection triangle multi hygienic refrigerator and Yeşim Textile Company is produced nano-structured smart fabrics that are iron easily, dry quickly and get dirty hardly and these fabrics have been exported to American textile company GAP.<sup>10</sup>

Turkey's future strategies for nanoscience and nanotechnology have been estimated and determined by the Scientific and Technological Research Council of Turkey (TUBITAK) which states the aims and objectives by the year 2023. According to the Nanoscience and Nanotechnology Strategies report of the TUBITAK the prior subjects concerning the nanotechnology are the following<sup>11</sup>:



- ❖ Nanophotonics-Nanoelectronics-Nanomagnetism with the aim of being an international production center for integrated circuit systems with nanostructures.
- ❖ Nanomaterials; aimed to produce advanced nanocomposite materials, bio-inspired materials and catalysts, production of nanoelectronic and nanomechanical devices by self-assembling method.
- ❖ Fuel Cells and Energy; plan to produce fuel cells with high efficiency
- ❖ Nanocharacterization; aimed to improve scanning probe microscopes and atomic force microscopes.
- ❖ Nanofabrication; aimed to produce nanostructures and integrated circuit systems with competency.
- ❖ Nanosized quantum information processing; aimed to be competent on designing, simulating and producing of nanoscale units
- ❖ Nanobiotechnology; plan to improve DNA diagnosis.

These quite few but impressive examples, the new developments and strategies combined with the qualified scientists puts Turkey in a hopeful position that there will be more qualified articles and industrial products will be produced in near future.

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### **Fullerenes and I—a personal memoir**

I never have worked on fullerenes myself but I was involved in a very modest way with the very early work that Harry Kroto and his colleagues at Sussex were doing. It was a very exciting time as you may imagine. I was at that time the leader of a group of some 20-odd (some of them *very* odd) scientists and engineers at the then London Research Station of the former British Gas plc's Research and Technology Division.

About 10-12 years ago, Steve Wood, a member of my group at work who was chiefly concerned with homogeneous gas phase reactions and particularly the way in which carbon was formed, came to see to me and said that a senior researcher at the University of Sussex, where he had been a graduate student and with which he still kept in touch, had some new ideas about the structure of carbon that he would like to come and talk to us about. Of course we all knew, indeed it was a matter of almost Biblical stature, that carbon existed either as diamond or as some form of graphitic structure of more or less well-ordered 3-D structure, and that was that.

Certainly, that's what every young student was taught: carbon only occurs in these two forms. It was all in the text books and had been for 100 years but we were curious to hear what this guy had to say, so Steve brought along a certain Dr. Harry Kroto to see us. Harry was a fairly relaxed and informal fellow, and indeed, he still is. The only time I've seen a picture of him wearing a tie was for the white-tie-and-tails uniform of Nobel Laureates. He was wearing an open-necked shirt when he came to see us and all his belongings and notes for his talk he carried in a sort of duffel bag on his shoulder but what he had to say really grabbed our attention. He explained that he was originally interested in what so-called star dust is made of, material that exists in inter-stellar space in huge quantities and in the course of his research on the subject he had joined up with two American colleagues. They were beating hell out of a lump of graphite with a very high-powered laser to see if the bits that came off were at all like what they thought this interstellar material might be. The thing that amazed them was that they kept on getting this huge mass spectrometer signal for a lump of material of mass 720 times that of a hydrogen atom. To a chemist this meant only one thing: they were looking at material that consisted of 60 carbons only, just that and nothing else,  $C_{60}$  in other words. There was another corresponding to  $C_{70}$ . Two questions immediately came into their minds. Why on earth was this particular combination so stable, there was no signal for  $C_{59}$  or  $C_{61}$  for example, and then how on earth could it consist only of carbon? You could tear pieces of 60 carbon atoms from graphite by brute force like thumping it with a laser beam: no problem there. The problem was that the piece would be quite unstable because the atoms that had been torn from their neighbours in this way would be very keen to react with any other passing atom or molecule like hydrogen, oxygen or anything else that happened to

be around. This was just not happening:  $C_{60}$  was not only stable, it was relatively unreactive. What had they got here?

Well, we all know the answer now but as Harry said, they were really beating their brains out on this problem. They felt that this relatively big molecule was probably not flat, it was curved into a closed form but the problem then was that you can't take hexagons and bend them into a structure like that. We're talking about 20 hexagons being necessary to enclose this number of carbon atoms and if you try to do it yourself with bits of cardboard cut into hexagon shapes, you'll find that you just can't do it without severely straining, not to say completely buckling, some of the hexagons. Of course, what you *can* do as we now know, is to roll the hexagons into a sort of tube and this gives us nanotubes, which were coming onto the scene at the time. On the other hand, Harry knew that the famous American architect, Buckminster Fuller, had made his so-called geodesic domes basically out of hexagonal pieces, so it could be done on the big scale. As a matter of interest, there are some geodesic domes nearer home, in Cornwall in the Eden project, where they completely enclose an old china clay pit to make an artificial atmosphere for growing trees and plants.

The breakthrough came one day when Harry was looking at a floor pattern: I think he said he was on the loo at the time but I might have imagined this! He realised that they had got hooked on the hexagonal structure but carbon does exist as well in pentagons. If they were to combine 6-membered and 5-membered rings, could they close the structure? Quickly getting out paper and scissors they came up with the answer. If they took hexagons and pentagons they could make a closed structure that was practically a sphere with almost no strain in any of the rings. That was it! It was carbon structure that needed no hydrogen and had no dangling bonds but conserved  $sp^2$  bonding, which presumably gave extra stability. It was such an elegant and logical structure that they felt at once that it must exist in Nature or that it was well-known to mathematicians, so they called up the Maths. Department and asked them to see if they could match the structure by other, already known examples. After an hour or two, the mathematicians came back on the line. "We've found a match, OK." "That's great, what is it?" "It's a soccer ball". (Remember this was an *American* university where their footballs have a different shape). This is when the irreverent started calling them Buckyballs, a practice that seems to have diminished of late, I'm glad to see.

Anyway, that's the story of how Sir Harry Kroto, FRS, Nobel Laureate, Past President of the Royal Society of Chemistry, together with Profs. Robert Curl and Richard Smalley got his Nobel Prize. My own part in this? Well, I said it was modest. Having heard this fascinating tale, I felt that it was such a beautiful structure it must be the right one and we got Harry a small amount of money and a research student to try and make this stuff on big enough scale to do some chemistry on it and the rest as they say, is history. Harry and his colleagues needed to name this new structure and they decided to honour the great architect by calling it Buckminsterfullerene, a bit of a mouthful, quickly shortened to Fullerene and as we now know, fullerene chemistry is now an enormous subject not to

mention the fact that we now have to re-write the text books as carbon exists in 3 forms, not 2.

So if you wanted to see the structure of  $C_{60}$ , you didn't need to overheat the little grey cells: just smartly collect your son's football and look at it and there it was, hexagons and pentagons neatly sewn together. Like all great discoveries it was under their noses all the time. That was the story Harry told and I'm glad to report that we all felt in our waters that he was onto something really good. Our ability to fund relevant university work being fairly flexible at that time (ah, happy days!), we were able to scrape up some cash and to help fund a CASE student to help in the search for  $C_{60}$  and  $C_{70}$  on the macroscale. As a matter of interest, you may well have seen the student, now better known as Dr. Jonathan Hare, on the BBC TV programme "Rough Science" where his ingenuity is put to good use. In case Jonathan is reading this (or even if not), he turned out to be an excellent worker and he and his fellow student were literally working round the clock in shifts to get results ahead of the pack. The fact that they were just pipped at the post by their German rivals doesn't detract from their work. At the end, he did come and present Steve Wood with two small phials containing benzene solutions of  $C_{60}$  and  $C_{70}$ . (Have you still got them, Steve?). I gather that part of British Gas' cash was spent in buying the biggest welding transformer they could get hold of and was the central part of the fullerene-generating equipment.

Shortly after the Sussex group had published their results, the BCG convened a meeting in the RSC's Council Room at Burlington House, which I remember as being the most interesting and exciting meeting that I have ever attended. John Patrick, who was our Chairman at that time presided and with characteristic common sense produced a small football belonging to his grandson so that anyone who still might just conceivably not know, could see the structure of  $C_{60}$  in solid form. I seem to remember that he metaphorically donned sackcloth and ashes on behalf of the carbon community: as he wryly said, we had repeated too long the story about the essential flatness of carbon. It was the only meeting I've been to where chemists, physicists and mathematicians were all wanting a share of the action. Everyone was producing his latest thoughts and in many cases, some research results hot off the press.

The rest is history that someone more directly involved in it ought to recount some time. One immediate outcome was the series of **NanoteC** meetings supported by the BCG, held by the Sussex group and of international fame as being the centre for reporting really significant new work in the field of fullerenes and nanocarbons. They are I'm told, still as exciting now as they were in the beginning.

Not only that, but we had a postage stamp that had a picture of  $C_{60}$  on it. If you remember, there was even a little chemical joke attached, in that the stamp was printed with photochromic ink and if you put your warm finger on the  $C_{60}$  image, a guest molecule entrapped in it appeared. So, even the Great British Public has known about this fascinating discovery.

Norman Parkyns