The
British Carbon Group

Carbon Newsletter

Number 48 December 2015

Forthcoming meetings:

“Carbon at Christmas” December 17th

Carbon photographic competition

Meeting reports:

INGSM-16

BGC Spring meeting

Carbon 14 and Carbon 15

News and articles:

Carbon in Industry award 2015

Carbon science, architecture and art

SCI

ROYAL SOCIETY OF CHEMISTRY

IOP Institute of Physics

Editorial

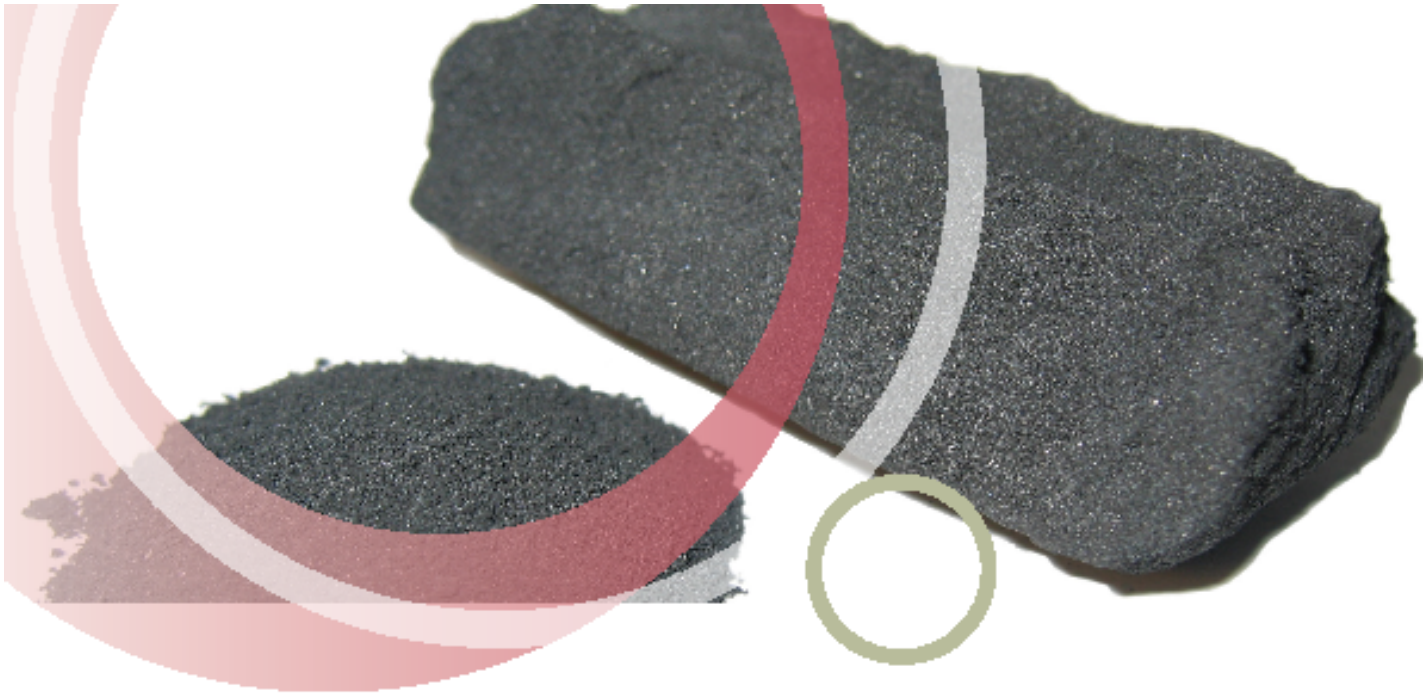
The past year has been very busy for the Group as indeed, it was last year. We have had a Spring meeting at Southampton as well as our annual NanoteC, this year in Oxford. In addition, Tony Wickham has organised on behalf of the Group, INGSM-the nuclear graphite specialists' meeting in Nottingham and we shall be holding a Christmas meeting this year at the SCI headquarters in London. There are two notices of the meeting here, one provided by the SCI who are hosting us this year, which give the full details, will incorporate a lecture by the winner of the "Carbon in Industry Award", Prof. Steve Tennison. The meeting will cover current and potential industrial applications of active carbon, diamond and graphene.

I should like to draw your attention to the photographic competition we are holding and for which the prize of £100 will be awarded at this meeting. Details are given in the meeting notices on pages 2 and 3 and on page 4. Our previous competition a few years back drew a lot of very imaginative entries, so we know the talent is out there.

It's also gratifying to note that the numbers of the British Carbon Group are steadily increasing and are probably the highest we have ever been. One of the major tasks of your committee is to try and bring together all the very disparate strands of research and activity in all the forms of carbon. As Editor, I would appeal for any reports on the activities of all the industrial and research groups out there. I know that most organisations have what Richard Nixon described as a silent majority but the silence at present is quite deafening. Any comments on carbon work or even opinions that you might be afraid to voice in a more august journal would be most welcome. I have not had to reject any offerings so far, so now is your chance. You might for example to publicise the work of your colleagues or let us have a brief account of an interesting research seminar that you may have held and in which others are likely to be interested. As an example of what could be acceptable, I should like to here to acknowledge the receipt of the interesting contribution from Peter Harris at Reading that appears near the end of this newsletter.

Finally, there is an increasing tendency for scientific groups to move towards electronic communication of their newsletters. We do this for the BCG in the sense that the contents of ours are posted on the BCG website for all to read, after a reasonable delay to allow you to read the paper version. This does save paper and the cost of printing what is seen as at least an informal professional publication and we are increasingly reminded by our sponsoring bodies for the need for economy. Because copies are sent overseas by airmail, this cost is disproportionately large and we have regretfully stopped sending hard copies outside the UK. I am doing my best to ensure that those of you thus affected get your individual copies by e-mail but we are up against the problem of junk mail filters, which are extremely fierce on university servers. Against going exclusively to this format is the fact that I am assured that many of you really appreciate having something that you can hold in your hand and read at your leisure in the train or wherever. Conventional printed copies of books are apparently still standing up well against the onslaughts of Kindle and other e-books, so this may well prove to the case for us as well.

Norman Parkyns *norman.parkyns@tesco.net*



Carbon at Christmas

17 December 2015

SCI, 14/15 Belgrave Square, London

A half day meeting will be held on Thursday 17 December 2015 at SCI devoted to UK carbon research.

Carbon at Christmas image competition (prize £100):
Send your entries (or an internet link to your entry) to m.heggie@surrey.ac.uk by Thurs 10 December 2015.
Entries can be on any aspect of any carbon. BCG committee will judge the entries and their decision is final. In entering the competition you agree that BCG may use the image in their publicity material.

Programme

- 13:00 Buffet lunch (free)
- 14:00 Welcome - Prof Malcolm Heggie, University of Surrey & Chair BCG
- 14:05 Nanoporous Carbons - New and Emerging Industrial Applications. Carbon in Industry Prize lecture - Prof Steve Tennison, MAST Carbon Ltd
- 15:05 Engineering Synthetic Diamond for Technological Applications - Dr Tim Mollart, Element Six Group
- 15:50 Tea and coffee
- 16:10 Proton transport through 2D crystals - Dr Marcelo Lozada-Hidalgo, The Graphene Centre, Manchester
- 16:55 Closing remarks and award of the Carbon at Christmas image prize
- 17:00 Departure

Delegate Fees
This is a free event - Booking required. **Registration deadline: Thurs 10 December 2015.**

Book today!

E: plvsmin@aol.com
T: +44 (0) 207 598 1584
www.soci.org/events

Organised by SCI, RSC and IOP British Carbon Group

ROYAL SOCIETY OF CHEMISTRY

IOP Institute of Physics

The British Carbon Group

SCI where science meets business

17 December 2015
13.00

Venue
The Society of Chemical Industry, 14/15 Belgrave Square, London SW1X 8PS

Registration email:
plvsmin@aol.com

BRITISH CARBON GROUP
Carbon at Christmas

The British Carbon Group

A half day meeting will be held on Thursday 17th December at the Society of Chemical Industry devoted to UK carbon research. There is no meeting fee, but you must register by email to plvsmin@aol.com ***by Thurs10th Dec.***

13.00 Buffet lunch (free)

14.00 Welcome – Prof. Malcolm Heggie, University of Surrey & Chair BCG

14.05 Prof. Steve Tennison, MAST Carbon Ltd. *Nanoporous carbons—New and emerging industrial applications*

(Carbon in Industry Prize lecture)

15.05 Dr. Tim Mollart, Element Six Group,
Engineering Synthetic Diamond for Technological Applications

15.50 Tea and coffee

16.10 Dr. Marcelo Lozada-Hidalgo, The Graphene Centre, Manchester,
Proton transport through 2D crystals

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The British Carbon Group (registered charity 207890) is affiliated to The Royal Society of Chemistry, The Institute of Physics and The Society of Chemical Industry

ROYAL SOCIETY OF CHEMISTRY

SCI

IOP Institute of Physics

Christmas meeting 2015

This year we are returning to London for our now traditional Christmas meeting. It will be held at the SCI headquarters at 14/15 Belgrave Square SW1X on 17th December, starting with a lunch at 1.00pm. The two flyers above, for the first of which I am indebted to Ester Monfort of the SCI, give the full details.

The meeting will be the occasion of the award of the SCI/BGC "Carbon in Industry" prize for 2015 to Prof. Steve Tennison and he will give the first lecture. We are trying to cover all the aspects of industrial applications of carbon so Dr Mollart of Element 6 will cover the uses of diamond and Dr Lozada-Hildago of the Graphene centre at Manchester will cover what will doubtless be future applications of graphene. There is no charge for the meeting although you are asked to register in advance so that we can judge the catering for the buffet lunch, which I might say, is also free. The SCI lecture theatre is an excellent, well-appointed and comfortable venue, so you have no excuse for not coming to what will be a very interesting afternoon meeting.

The final key point of attraction is the photographic competition for which we are offering a prize of £100. The only restriction is that it has to do with carbon in some way but that is barely a hindrance to letting your imagination run free. Our previous competition in 2008 "Capturing Carbon" produced an excellent set of entries and I hope the reproduce in the next newsletter not only the winning entry but also as many of the others as I can get in. I don't think you need necessarily work in both the themes of both carbon and Christmas but you might well get bonus points for imaginative flights of fancy in this direction. We might like to use any entries for publicity for the Group and I hope we shall be able to reproduce at least some in a subsequent newsletter.

Future meetings

Medical Applications of Novel Biomaterials and Nanotechnology

CIMTEC 2016

June 5-9, 2016, Perugia, Italy

The conference, that follows the same subject held in previous CIMTEC editions, will highlight recent progress in the synthesis and characterization of new or creatively modified stimuli-responsive, active and multifunctional metals, ceramics, polymers, gels; smart nanoparticles, functionalized 1-D and 2.D nanostructures, Q-dots; hybrid, composites, self-organized materials, hierarchical bio-nanostructures, as well as the prospectives for their further use in selected challenging areas of nanomedicine such as: multi-scale approaches to regenerate and engineer new soft and hard tissue; innovative targeted drug delivery and release platforms; and new materials systems for medical imaging/therapy including multi-modal theranostics. Materials issues for implantable neural interfaces and the opportunities and challenges of applications of carbon nanotubes and graphene in medicine will be object of two Focused Sessions.

Overall, the study of systemic interactions in the body such as side effects, biocompatibility and biofunctionality will be essential issues to promote the discussion for bioinspired strategies in materials and device design to be effectively implemented into clinical practice.

CIMTEC 2016 will gather together a large and qualified audience of materials scientists, physicists, chemists, biologists, physicians and engineers, as well as experts of a wide range of the most advanced and demanding research and application areas of smart materials and related technologies. On the top of this premier event in materials, the Umbria region will offer its wonderful landscape and its immense, unique artistic heritage!

Learn more about **CIMTEC** Conferences

Symposium F

Graphene and Other Emerging 2D-layered Nanomaterials: Synthesis, Properties and Potential Applications

5th International Conference

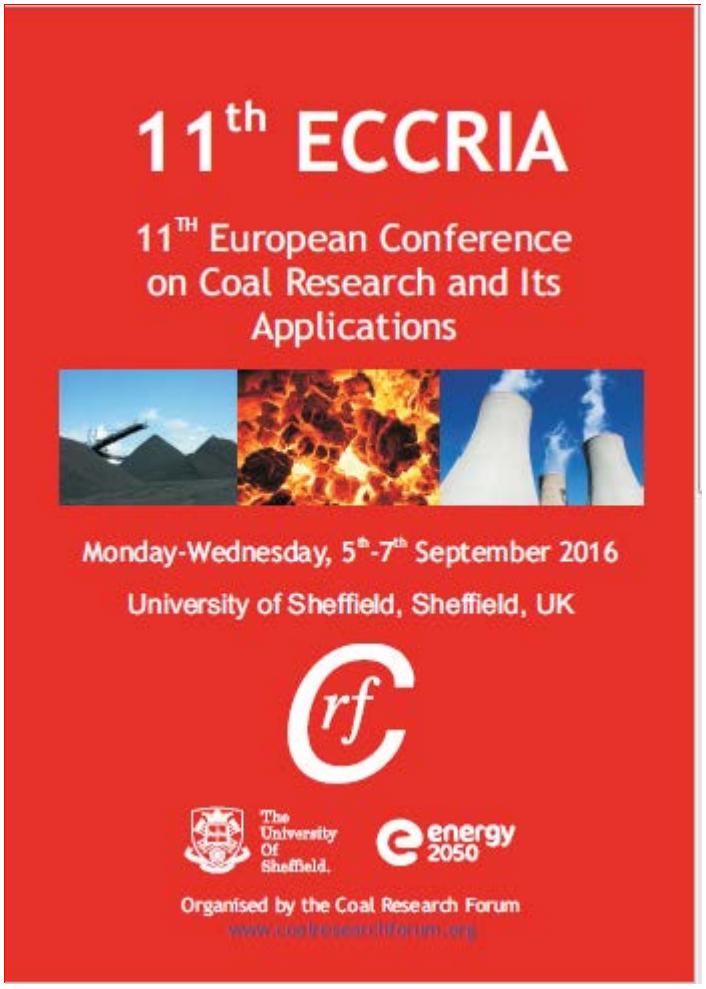
Smart and Multifunctional Materials, Structures and Systems

CIMTEC 2016

June 5-9, 2016, Perugia, Italy

This symposium aims to highlight recent progress in the synthesis of graphene and novel 2D layered materials (nitrides, dichalcogenites, oxides, silicene …) including various doping, alloy-forming, hierarchical, multifunctional, tunable and switchable architectures, heterostructures, hybrid superstructures and nanocomposites. Predictable structure-property correlations, state-of-the-art characterization and modelling of structure, chemistry and electronic, optical, electrochemical, mechanical and thermal properties and in testing of performance in devices will be also of interest as well as novel production processes for cost-effective and scalable growth of low-defective graphene and other 2D layered nanostructures and in techniques for their integration into electronic, optical, optoelectronic and electromechanical devices for ongoing and potential applications in energy, environmental, mechanical and biomedical fields.

Eccria 2016



Further Information;

www.rnaggichurchouseevents.co.uk/crf

www.coalresearchforum.org

Advances and Applications in Carbon Related Nanomaterials: From Pure to Doping including Heteroatom Layers

Benasque (Aragon-Spain) on 7–11 December 2015.

"HeteroNanoCarb 2015"

http://heteronanocarb.org/

Attendance will be limited to 100 participants

If you have any inquiry, please contact heteronanocarb@unizar.es

Chairman: **R. Arenal** (U. Zaragoza, Spain)

Co-chairs: **C.P. Ewels** (CNRS - U. Nantes, France); **D. Golberg** (NIMS and U. Tsukuba, Japan); **V. Meunier** (Rensselear Polytechnic Institute, USA); **A. Rubio** (MPSD Max Planck Institute fro the Structure and Dynamics of Matter, Hamburg, Germany and U. Pais Vasco, Spain)

List of Invited Speakers

Prof **Marija Drndić** (University of Pennsylvania, USA)

Dr. **Vincent Dusastre** (Nature Publishing Group, UK)

Prof. **Tony F. Heinz** (Columbia University, USA)

Prof. **Arkadi V. Krasheninnikov** (University, Finland)

Prof. **Klaus Mullen** (Max Planck Institute for Polymer Research, Germany)

Prof. **Stephanie Reich** (Free University of Berlin, Germany)

Prof. **Rodney Ruoff** (University of Texas, USA)

Prof. **Odile Stephan** (Paris-Sud Orsay University, France)

Prof. **Kazu Suenaga** (AIST, Japan)

Prof. **Nikos Tagmatarchis** (National Hellenic Research Foundation, Greece)

Prof. **Oliver A. Williams** (Cardiff University, UK)

Prof. **Jorg Wrachtrup** (Stuttgart University, Germany)

(NOTE: The registration date for this meeting has closed but any interest in it may be registered at one of the contacts above.)

News items

Carbon in Industry prize 2015

The SCI/BGC Carbon in Industry prize for 2015 has been awarded to Prof. Steve Tennison. Steve began his career at BP Research in the Sunbury labs. He worked for many years on active carbons and in particular how to control the porosity for different applications. During this period, he and his group produced a novel catalyst, based on caesium-promoted ruthenium on carbon, for the synthesis of ammonia, the first commercially successful development since Haber's original iron catalyst. This is now in use in six of the World's largest ammonia plants. However the realisation of the problems inherent in conventional activated carbons lead to the development of the polymer derived carbons that form the foundation of the current company.

He left BP to set up MAST Carbon International with a colleague to exploit commercially the special adsorptive properties of carbons in industrial applications. The factory at Basingstoke has the capacity to produce carbons for a variety of purposes. The main use is of carbon cloth, which is used in a great variety of applications for removal of noxious materials, in military protection against CBR and in specialist medical applications. The company has a number of R&D projects funded internationally. Steve himself is an active member of the British Carbon Group, a Fellow of the Royal Society of Chemistry and a visiting professor at the University of Bath. He gave one of the prestigious Ubbelohde lectures to the BCG in 2008.

Prof. Tennison will be giving the prize lecture at the "Carbon at Christmas" meeting at the SCI on Dec 17th

Meeting reports

8th Ubbelohde lecture September 2015

The award of the 8th Ubbelohde lecture was made to and given by Prof. Peter Thrower at the recent INSGM at Nottingham. It started off the scientific programme on the Monday morning. I was asked, as one of his former students, to say a few words about Prof. Ubbelohde after which Prof. Malcolm Heggie as Chairman of the BGC introduced the lecturer. Prof Thower has had a long and distinguished career and is known to all in the field as a long –time editor-in-chief of the journal Carbon as well as the review series Chemistry and Physics of Carbon: he is a Professor Emeritus of Penn State University where he worked for many years.

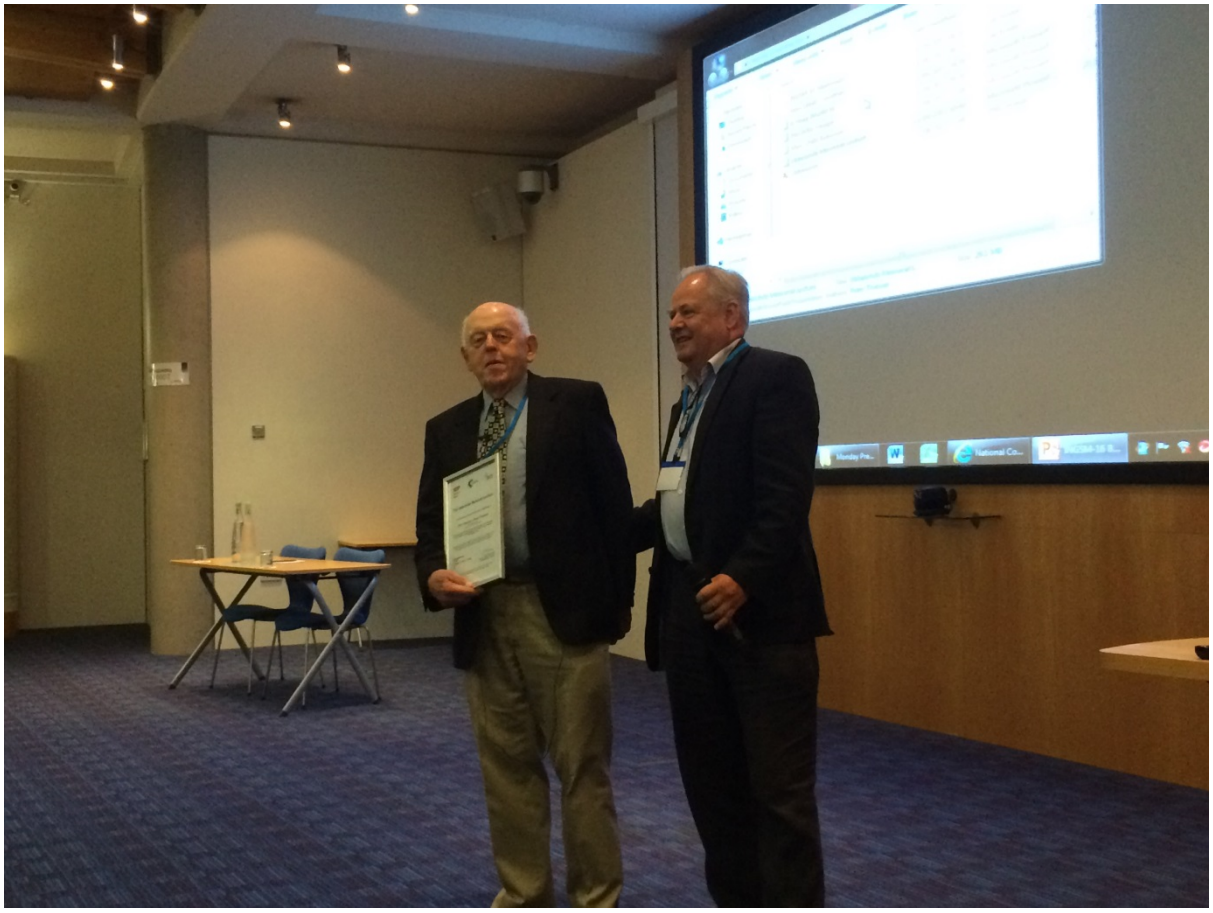
Prof. Thrower's lecture was partly along the lines of a review of his life's work in graphite. This was entirely appropriate because the INSGM meeting was largely devoted to the latest developments in the science and technology of the degradation of graphite during exposure to nuclear radiation in reactors. He said that he had started as a young Scientific Officer at the AERE Harwell in 1960 and had not been expecting to work in the area to which he was assigned. Very early on he was part of the team that was overseeing BEPO, an air-cooled reactor which had to be carefully monitored during a controlled release of Wigner energy. His own work used an electron microscope to monitor radiation damage in graphite. He caused some amusement in the audience by recalling that he worked out that the only way he could make specimens thin enough to use in the microscope was by stripping off layers of graphite using Sellotape (Scotch tape) until he got to the required thinness. As he said, he missed getting a Nobel prize by a few atomic layers.

One of his colleagues around that time was a young man called John Thomas who had predicted some time before that the release of the stored Wigner energy in an air-cooled reactor was sufficiently great to cause an uncontrollable rise in temperature to cause problems, as indeed had happened at Windscale in 1957. As a result, Harwell did have rigs to examine this possibility. Prof. Thrower wondered if Sir John Meurig Thomas remembers these days. He did also have some second-hand contact with Prof. Ubbelohde who was asking them for graphite samples but he never heard what happened to them.

The work at Harwell on heating graphite was done in vacuo at 1500^0C but there was some work in parallel done at Cambridge at 3000^0C. The effect on sintering was very marked different in these two sets of experiments and it turned out that the work at Cambridge was contaminated by boron that evaporated from the walls of the furnace at these very high temperatures. This turned out to be a very useful effect and led to a better understanding of annealing defects in graphite. During this work he proposed two separate mechanisms for annealing, homogeneous and heterogeneous. He was also able to distinguish between hole and interstitial defects by selective tilting of the specimens in the electron microscope.

In the mid-60s, he said he was fortunate enough to publish two major papers based on an observation of the differences shown by cleaving graphite crystals before and after neutron irradiation. Around that time, Hennig published some striking micrographs of graphite that had been etched with chlorine and other materials to encourage vacancies and then decorating them with gold. Diffusion rates could be determined and the data showed that in the a and c axes, the activation energy was identical but that there was a thousand-fold difference in the pre-exponential factors. This remains unexplained today. Similarly, some of the other properties of graphite show isotropic properties and these also lack as yet a coherent explanation.

He mentioned some other areas that still remain unresolved. For example mechanical grinding of graphite natural crystals produces changes in d spacing that are similar to those observed in 1965 by neutron irradiation. Among his concluding remarks was to notice that the concept of a vacancy line as a mechanism of annealing he proposed many years ago has received increasing attention today.



The picture shows Prof. Thrower (on left) being presented with the Ubbelohde lecture commemorative certificate. Picture courtesy of Dr. Cristian I. Contescu, Oak Ridge National Laboratory, to whom I am indebted.

In presenting Prof. Thrower with the commemorative certificate for the 8th Ubbelohde lecture, Malcolm Heggie said that in addition to the that award, he was pleased to say that the British Carbon Group had awarded him Honorary Life membership.

The contributed papers to the INGSM started with a presentation by Prof. Heggie where he entertained the audience by comparing the various types of defect in graphite to the characters in Luigi Pirandello's play "Six characters in search of an author" although he had only four to deal with here. He described the nature of the defects in turn in terms of their human equivalent and how these properties could be healed by the application of what he called Density Functional Therapy *(sic).* It was a nice conceit, well-brought off and complemented the tone of Peter Thrower's lecture rather effectively.

I apologise to Prof. Thrower in advance for any inaccuracies or misrepresentation in this account. They are entirely to be attributable to your correspondent who takes entire responsibility for them.

Norman Parkyns

Sixteenth International Nuclear Graphite Specialists' Meeting – INGSM-16

The National College for Teaching and Leadership, Nottingham
13th – 17th September 2015

The INGSM meeting series began in 2000 at the Oak Ridge National Laboratory in Tennessee, when 20 people annoyed by the loss of nuclear sessions at world carbon conferences took up a suggestion from a meeting at the International Atomic Energy Agency (IAEA) to start their own. There was encouragement from the British nuclear regulator to have meetings where experts would openly discuss their problems as well as their successes, fostering international collaboration and contributing to overall nuclear safety.

The British Carbon Group has been proud to host three of these meetings – firstly at Plas Tan-Y-Bwlch in Wales, then at Eastbourne, and now in (sunny?) Nottingham. Over ninety delegates attending this meeting, which was the largest INGSM ever if you discount the large number of unexplained Chinese people who showed up for the first morning only at last year's meeting in Hangzhou!

The opening ice-breaker event presented by the African drumming and bushwhacker group 'Drum Cafe' (well, from South London really) came as a surprise to everyone except me and was well received: the meeting proper opened on the Monday morning with the 8th Ubbelohde lecture presented by Prof Peter Thrower, which is reported above in this newsletter. Subsequently, an astonishing 59 presentations were given on all aspects of nuclear graphite: understandably, the majority this year concerned the long-term behaviour of the cores of the UK advanced gas-cooled reactors, some of which have now operated for more than 40 years. Another important topic was the development of the understanding of irradiation creep in graphite, both through new experimental work in the USA and The Netherlands on behalf of the UK programme and also the US graphite-moderated 'Next Generation Nuclear Plant' concept – this is accompanied by an IAEA collaborative research programme in the area in which the UK has played a major role.

Within the conference we also heard about the latest developments in the Chinese molten-salt reactor project, the re-awakening of the Japanese high-temperature reactor research (aimed at hydrogen production for fuel alongside the electrical output), and the efforts of a number of companies around the world to produce the perfect graphite for future HTRs wherever they may be built.

There was time for relaxation too, with trips arranged to Chatsworth House in Derbyshire and to the local caves which lie under the centre of the city of Nottingham, which very usefully provide a home for the famous 'Trip to Jerusalem' Inn.

Everyone seemed very happy with the programme and the venue, with in-house accommodation, is highly recommended for any conference event with hospitable staff and a welcoming environment.

Next year the event goes 'home' to the IAEA itself (in Vienna, Austria) from 5th – 8th September 2016, and the BCG will be managing this again on their behalf. More information in due course from www.britishcarbon.org/ingsm and from Tony Wickham at confer@globalnet.co.uk.

Tony Wickham

BCG Spring meeting, April15th 2015

This year, we had a Spring meeting at Southampton, by kind invitation of BAT. About 40 attended what was a very interesting and varied programme, which covered the whole area of different forms of carbon. It was held in the newly-furbished lecture suite of BAT with all mod. cons., on the audio/visual side. We also managed (just) to squeeze in the Group's AGM at the end, the programme having over-run a bit, such was the interest generated in the discussion sessions after each lecture. We were also grateful to BAT for provided us with lunch and refreshments on the day, as well as a reception on the evening before for those staying overnight. The final programme is shown below.

09:30 Arrival and Coffee

10:00 Welcome and Introductions

10:15 Industrial applications of diamond electrodes

Prof Julie McPherson, Warwick University

10:45 Perspectives on Coking

Colin Atkinson, Materials Processing Institute, UK

11:15 Nuclear Graphite: the first 73 Years and the next 100,000

Prof Tony Wickham, Manchester University

11:45 Recycling of carbon from pyrolysis of tyres

Dr Ahmed Farid, ARTIS

12:15 Lunch and networking.

13:30 Nanostructured carbon adsorbents for medical protection against CBRN hazards

Prof Sergey Mikhalovsky, Brighton University

14:00 Graphene - why the excitement?

Dr Andy Goodwin, Thomas Swan & Co. Ltd.

14:30 Carbon past and future perspectives

Gareth Neighbour, Oxford Brookes University

15:00 AGM of BCG

Tea and Coffee. Optional tour of BAT Research Facilities (GR&D)

16:30 Depart

The first talk, by Prof Macpherson, was devoted to the use of diamond as electrode material in electrochemical applications. It seems that diamond is uniquely suited to this sort of use because of its surface inertness, compared to say, an active metal like platinum. Diamond is normally practically an insulator or at least a semi-conductor with a very large band gap. However, doping with boron changes this progressively to one of much lower band gap and

ultimately, replacement of 1/1000 carbon atoms by boron makes it a black metallic conductor. This renders it useable as an electrode material.

The electrodes were prepared by the company Element 6 using the CVD technique up to a thickness of 500µm. They are thermally resistant to very high temperatures, have low thermal expansion and are chemically inert. They are particularly useful for long-term monitoring. The electrically conducting electrode material is deposited on a non-conducting diamond substrate, one great advantage of CVD being that it is easy to make electrodes of different geometries. Quality control of the deposited layer is monitored by Raman spectroscopy, and especially for the absence of a band at 1600 cm^{-1} associated with sp^2 carbon bonds.

In use in electrochemistry, different reactions can be followed in situ by varying the electrode potential. A typical example is monitoring Hg^{2+} levels where it is reduced to Hg^0 but where the deposited metal can be stripped off afterwards. Waste water can be cleaned up by producing OH^- ions that are very reactive and also clean up the electrode surface from organic contaminants.

Measurement of metal concentrations at the ppb (10^{-9}) level is increasingly important. These can be concentrated at the electrode surface by sweeping the electrode potential and the concentration is now sufficiently great to allow the use of XRF to identify the various metallic species at the ppm (10^{-6}) level.

Dr Atkinson's talk on coking brought back memories for me of the earlier period of the Gas Industry where coal was the principal source of gas-making. His organisation, the Materials Processing Institute, has been spun off from the steel and carbonisation industries to act in a consultant role generally. He described various techniques and facilities that were in use for advancing the use of coke in steelmaking. Vertical coke-ovens were still in use in the UK and the bye-products still remained articles of commerce.

Tony Wickham presented an overview of the use of graphite in nuclear reactors that was both retrospective and prospective. Initially, graphite was used as a moderator in the production of arms grade plutonium. He showed us a piece of the graphite used by Fermi in the reactor at Chicago in 1942, which I should have thought must be a unique specimen in the UK. He explained that graphite has a number of advantages for use as a moderator, other than slowing neutrons down. It is very hard and strong, although care has to be taken to exclude trace of other neutron moderators like boron while the rods and other shapes are made. Its thermal capacity is also an advantage when a reactor has to be shut down suddenly because the heat generated by residual radioactivity in the reactor has to be accommodated: at Fukushima the absence of graphite moderator led to secondary explosions when the cooling water failed.

The nuclear graphite is made from coke and pitch, care being taken to exclude not only boron but also chlorine as this could lead to stress corrosion cracking of stainless steel components in the reactor. It undergoes various stages of treatment until final graphitisation at 2800^0. One of the most important aspects of the use of graphite is that of radiation damage by the neutrons and this remains an important area of research. Dimensional changes and attack by CO_2 are other problems. His prospective view concerned what to do with the graphite that is removed from reactors when they are taken out of use. The used graphite has excessive amounts of C_{14} as a result of exposure in the reactor: this

has half-life of about 5700 years and is thus going to be around for the next 100,000. Currently, it is stored but other methods of dealing with it are under investigation.

Ahmed Farid from ARTIS then talked about the use of carbon black as filler in the manufacture of rubber. His main point was that carbon black is not just an inert filler as might be thought but is an essential component in the final product because of its interaction with the rubber polymer molecules. The carbon blacks are made by controlled combustion/pyrolysis of hydrocarbons, 90% of the product being used for tyres and other similar items. The basic particle size is in the tens of nanometre range and this does influence the properties of the final rubber, especially hardness. The entanglement of long polymer chains with the spherical carbon particles gives the rubber its elastic properties, while at the same time preventing creep, which would be undesirable. The final cross-linking of polymer chains is carried out traditionally by reacting with sulphur.

The next talk, by Sergei Mikhailovsky started off by chilling our blood about the possible terrorist use of Chemical, Biological and Nuclear Radiation (CBRN). He questioned whether we were prepared for such events but then went on to explain how active carbon might well be an excellent form of treatment to victims of CBRN. The US FDA has approved the use of some materials to treat ingestion of radionuclides, although the materials themselves had not been tested extensively for toxicity themselves. Presumably the victims are reckoned to be desperate enough not to insist on such niceties. Carbon absorbents may well have a similar role to play even though they likewise have not been tested for long term effects.

The first use of carbon as an antidote to poisoning was demonstrated early in the 19th century when a French pharmacist amazed an audience of the French Academy of Sciences by swallowing a fatal dose of strychnine followed immediately by ingestion of charcoal from which he survived apparently unharmed (he must have been a brave man and very certain of his researches). Sergei then revealed that he came from Ukraine, which we already knew, and had been working at Chernobyl which came as news to me. As a result, he was involved in the treatment of those who had been exposed to massive doses of nuclear radiation. They had found that those who had been treated by ingestion of active carbon survived with rapid and effective removal of the nuclides through the body. Sadly, a parallel group treated by an American expert using a different technique nearly all died. Sergei is pursuing his work currently.

Commercial production of graphene was the topic for Andy Goodwin of Thomas Swan. His firm produced specialty chemicals, hence their interest in making graphene. It has been the subject of intense curiosity since its isolation a decade ago: so far, tennis rackets, conductive inks and electric lights had been made from graphene materials. Some estimates have predicted a market worth $390 million by 2024 but of course, this does depend on graphene being available at a reasonable price. Thomas Swan were now manufacturing graphene by what was described as a high shear process up to the pilot scale of about 100kg/day (I may have got this wrong, my notes being unclear at this point). Andy thought that graphene might be the first in a series of 2D materials with immense industrial potential.

The final talk by Gareth Neighbour, the immediate past-Chair of the BCG, was very much a reminiscence of his experience during his career with carbon and graphite. In his present post at Oxford Brookes University, he had become increasingly involved with the development of racing cars, Oxford being very well placed geographically for such interactions and Oxford Brookes in particular being very active in industrial applications of science and technology. He showed us some rather glamorous pictures of the MacLaren

factory, if that is what one can call it, with which he and his students had been particularly concerned. It was a very entertaining end to what had been an excellent day's programme.

We are very much indebted to BAT for their hospitality and particular thanks must go to Peter Branton for put the programme together and getting such a broad spectrum of "the many faces of carbon".

Norman Parkyns

Report for Carbon Conference 2014

Attending the Carbon Conference 2014 in Jeju-do, Korea, it was a great experience for myself I have to say. My first ever trip to Asia, combined with the excitement and the stress for my oral presentation to the conference, made the whole situation an amazing experience. The Korean experience contained a whole package of the Asian hospitality, together with great food, beautiful landscape and relaxation. In addition, there was also some work as the main reason of this journey was the World Carbon Conference, held at the beautiful Jeju Island in South Korea from the 29th June until 4th July 2014.

Jeju is the largest island in South Korea and was designated Biosphere Reserve in 2002, World Natural Heritage in 2007 and Global Geopark in 2010, making the sub-tropical island the only place on Earth to receive all three UNESCO designations in natural sciences. The conference was divided into few sections: T1-Graphene, T2-CNTs and Related Carbon Nanomaterials, T3-Precursors, Carbon Fibers and Composites, T4-Industrial Graphites, Carbon Industry News and Carbon Blacks, T5-Porous Carbons, Carbons for Health and Environmental Protection, T6-Carbons for Sustainable Energy Conversion and Storage, and Carbons for Energy Saving, T7-Analysis, Characterization, Computation and Modelling of Carbons.

During the conference, I had an oral presentation entitled "Biofuels, Chemicals and Catalysts from Biomass via Hydrothermal Carbonization (HTC)". The oral presentation was a success, depending on the comments made by chairmen, my supervisor and people attending the session. My attendance on the Carbon Conference was also a good chance to present some preliminary results of my project and, of course, to discuss and be advised about the rest of my work. On the conference, I mainly focused on presentations related to porous materials from carbon, pyrolysis projects and analysis and characterization presentations. (T5 and T7 sections). As my research is mainly connected to carbon materials obtained from biomass via Hydrothermal Carbonization and their characterization, I focused my interest mainly on these subjects and presentations, trying also to interact with other researchers on this field of carbon chemistry. The conference also gave me the chance to come in touch with people from industry, talking about future collaborations and internships. Finally, the conference gave to all the attendees the chance to meet with each other. It was a great opportunity to meet in Jeju, people I have already seen in other places around the world, discussing about research and of course enjoying ourselves.

As the next World Conference on Carbon will be held in Dresden, Germany in 2015, I look forward to present al my new results regarding Hydrothermal Carbonization of biomass and

the production of valuable catalysts, fuels and chemicals via HTC. It is also a great chance for friends to meet there and come in touch with the German mentality and civilization.

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Annual World Conference on Carbon - Carbon 2015

The Conference CARBON this year took place in Dresden from 12th to 17th July 2015. Carbon Conference is one of the top in the area of Carbon Materials and my participation there gave me the chance to be among great scientists and people, who will further guide me and help me for my research. As a PhD student, I was given the chance to have an oral presentation entitled: "Phosphorus-nitrogen doped carbon for electrochemical purposes". It gave me the chance to present my work and my research to a broad "carbon" scientific audience.

The main motivation behind my work is the production of sustainable materials from renewable resources for energy conversion and storage. Here, fuel cells are promising candidates. Fuel cell reactions involve an ORR at the cathode surface. At the current state Platinum and Pt-alloys are the most practical used catalysts. These metals are estimated to last at the current rate of consumption for another 200 years (or even less). Therefore, there Is a need to find out new sustainable catalysts. Nitrogen is by far the most prominent doping candidate with versatile applications in electrochemistry. The introduction of N atoms into carbon frameworks with lone electron pairs can provide additional negative charges to the delocalized p system and thus leads to a significant improvement in the interaction between carbon structures and foreign molecules. It is also possible by simple thermal decomposition of low-cost precursor (such as chitosan) in a nitrogen atmosphere, the nitrogen/phosphorus dual-doped porous carbonaceous materials can be prepared.

With over 300 oral presentations and 4 plenary lectures the Conference helped everyone to interact with other researchers and potentially exchange between academia and industry. This year were also honoured outstanding scientific and technological contributions In the field of carbon materials and related materials.

The purpose of the Carbon Conference is to provide a platform for the discussion in carbon related topics. Carton has attracted much attention because of their fascinating properties and a wide range of applications. The annual conference Is a good place for exciting collaborations. For early-stage researchers the networks training is always valuable in their further career. Therefore I greatly appreciate financial support from the Royal Society of Chemistry (Materials Chemistry Division) through Travel Grant as well as from the British Carbon Group.

The Conference Dinner took place on Thursday. 16"' of July at the castle of Proschwitz. In the region of Meissen, famous for its porcelain. There was an opportunity to taste local wine In environment accompanied by fire (and not only) performances of local artists.

A beautiful capstone was Scientific Friday during which In a round trip (by bus) research centres were visited as well as Dresden University's Institute of Lightweight Engineering and Polymer Technology. Fraunhofer-Institut fur Keramische Technologien und Systeme. IKTS Dresden, and the Leibniz Institute of Polymer Research Dresden.

Summarising. a participation in a world-known conference is a credible opportunity for scientific development.

Maria Rybarczyk

Fourth Zing electrochemistry conference 2015

The 4th Zing Electrochemistry meeting that took place in Algarve, Portugal hosted around 50-60 academics at a beautiful venue over a few days. There were quite a mix of researchers from the Europe, Japan and the Americas presenting with talks on nano-electrochemistry, corrosion chemistry and next generation energy storage systems. My personal highlights were Richard McCreery's (University of Alberta) plenary talk on molecular junction electrodes which are being commercialised in electric guitar amplifiers, Susumu Kuwabata's (Osaka University) presentation of in-situ scanning electron microscopic *videos* of nanoparticle growth and Hubert Girault's (who recently left École Polytechnique Federale de Lausanne) perspectives on an energy storage (and distribution) revolution based on liquid-liquid redox systems. There was a good mix of applied and fundamental research presented, the quality of which were absolutely superb.

It was great being at a relatively small meeting as I could catch a quick conversation with 'big names' in the field with relatively little effort. Presenting my work in front of such distinguished audience members was a bit more intimidating than usual but it turned out to be a positive experience for me as I received positive feedback and new suggestions which I genuinely think may be worth pursuing. I guess this is what networking and conferences are all about? Feedback or getting any sort of attention for that matter means quite a lot to young researchers like myself and I am grateful for the opportunity to be there as it just would not have been possible without financial support from the British Carbon group and the RSC Electrochemistry group.

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Carbon science, architecture and art

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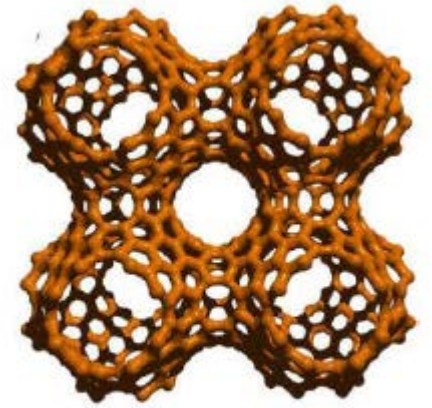
The original name for C60, buckminsterfullerene, is not much used these days, which is rather a shame as it draws attention to the links between carbon structures and architecture. As is well known, Harry Kroto coined the name when he realised the similarities between the icosahedral C60 structure and the geodesic domes designed by the visionary architect and inventor Buckminster Fuller. In each case the curvature results from the presence of pentagonal rings distributed among hexagons. Introducing pentagons into a hexagonal lattice can produce domes, cones and spheroids, but a far greater range of structures can be created when one introduces rings with more than six members. This has not escaped the notice of architects and artists, who have created some spectacular structures by inserting heptagons and other large rings, as well as pentagons, into hexagonal networks. In some cases these have been inspired by developments in carbon science.

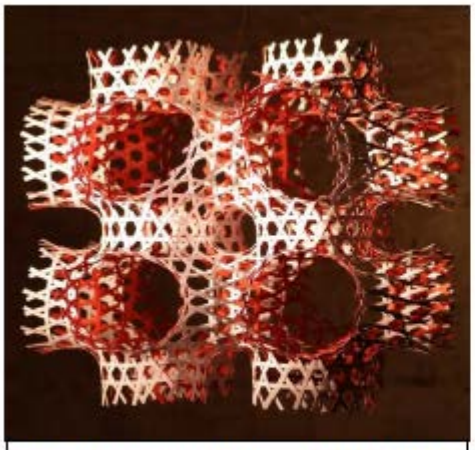


Schwarzite containing hexagonal and octagonal rings.

All-carbon structures containing rings with more than six members were first put forward by Alan Mackay and Humberto Terrones in 1991. The structures they postulated were based on the concept of triply periodic minimal surfaces, which was first described by the mathematician Hermann Schwarz in the 19th century. In order to produce a carbon lattice, Schwarz's surfaces were covered with a network containing heptagons and other large carbon rings as well as hexagons. The large rings introduce negative, i.e. saddle-like, curvature into the structure. Mackay and Terrones dubbed the porous structures schwarzites. An example of a schwarzite, taken from the work of Humberto Terrones and his brother Mauricio is shown on the left.

Another class of all-carbon structures which have been considered by the Terrones brothers and their colleagues are haeckelites, named in honour of Ernst Haeckel's beautiful diagrams of radiolaria. These consist of ordered arrangements of pentagons, hexagons, and heptagons, and can either be flat or tubular.

Unfortunately neither schwarzites or haeckelites have yet been synthesised in the laboratory; the technical challenge of doing so is formidable. Things are much simpler for artists and architects, who can simply use struts of plastic, metal or other materials to make their constructions, and are not constrained by the laws of chemistry. A number of artists have created works which bear a striking resemblance to schwarzites and related all-carbon structures. One of these is Alison Martin, a weaver based in Italy who uses split bamboo strips to make hexagonal meshes containing non-hexagonal rings. She is influenced by the Japanese art of kagome weaving, a traditional craft used in basket making.



Intertwined Labyrinths by Alison Martin

Morigami Jin's Reclining II

Morigami Jin is a Japanese artist who also uses kagome weaving to create abstract sculptures which represent a bridge between the worlds of craft and fine art: examples of his work are held in some of the world's leading galleries, including the Metropolitan Museum in New York. As can be seen in the example above, he creates highly complex shapes incorporating both positive and negative curvature.

Part of "Lunar Dome", an installation in Dubai created by Loop.pH

In the UK, Loop.pH is a "spatial laboratory" founded in 2003 by the designers Mathias Gmachl and Rachel Wingfield to create "visionary experiences and environments" including sculptures, some of which are distinctly schwarzite-like. The structures are woven from carbon fibre reinforced polymer strands, and look particularly stunning when illuminated, as shown in the picture above. Like the Terrones brothers, Loop.pH have also been inspired by Haeckel's radiolaria drawings.

The work of these artists and architects demonstrates the range of beautiful structures which can be made by simply incorporating non-hexagonal rings into hexagonal networks. The challenge for us scientists is to achieve the degree of synthetic control that would enable us to build such structures from carbon atoms.

Acknowledgement

I am very grateful to John Harding for drawing my attention to the work of Loop.pH.

Websites

Work by Alison Martin:

https://www.flickr.com/photos/109333486@N07/

Video about Morigami Jin:

https://www.youtube.com/watch?v=UHepgBVPMFI

Loop.pH:

http://loop.ph/

A last word

Years ago, like many of you no doubt, I used to be sent on management courses, generally without enthusiasm but I have to admit that some at least did turn out to be useful. One of them, on management of R&D as I remember, did include a very entertaining presentation by someone from BP who was former senior director of what was then called Personnel: now Human Resources of course, but still the bane of all productive members of any organisation. He was probably untypical of the breed but as I say, was entertaining and unconventional in his views, about personnel anyway and he told us a rather nice tale that I thought might give you a chuckle.

It seems that a bright and idealistic young graduate applied for a job in a large firm. He found himself in front of someone from Personnel who took him through the bread and butter part of the interview, which was the conventional sort of thing. At the end of half an hour of this he asked the young applicant if he had any questions about anything that had been covered. The applicant being young and inexperienced in interviews found his mind a complete blank but feeling that he had to say something blurted out “How many people work here?” “Oh, about half of them I should think“ was the unexpected reply.

On that unsettling note, the interview was concluded and the young man departed. He was however offered, and duly accepted, a job in the firm. He had been working there for a few months, when he bumped into the Personnel man in a corridor. “Oh hello” said the latter. “Glad to see you took the job. Which half have you joined?”

Happy Christmas