Chemistry IN NEW ZEALAND

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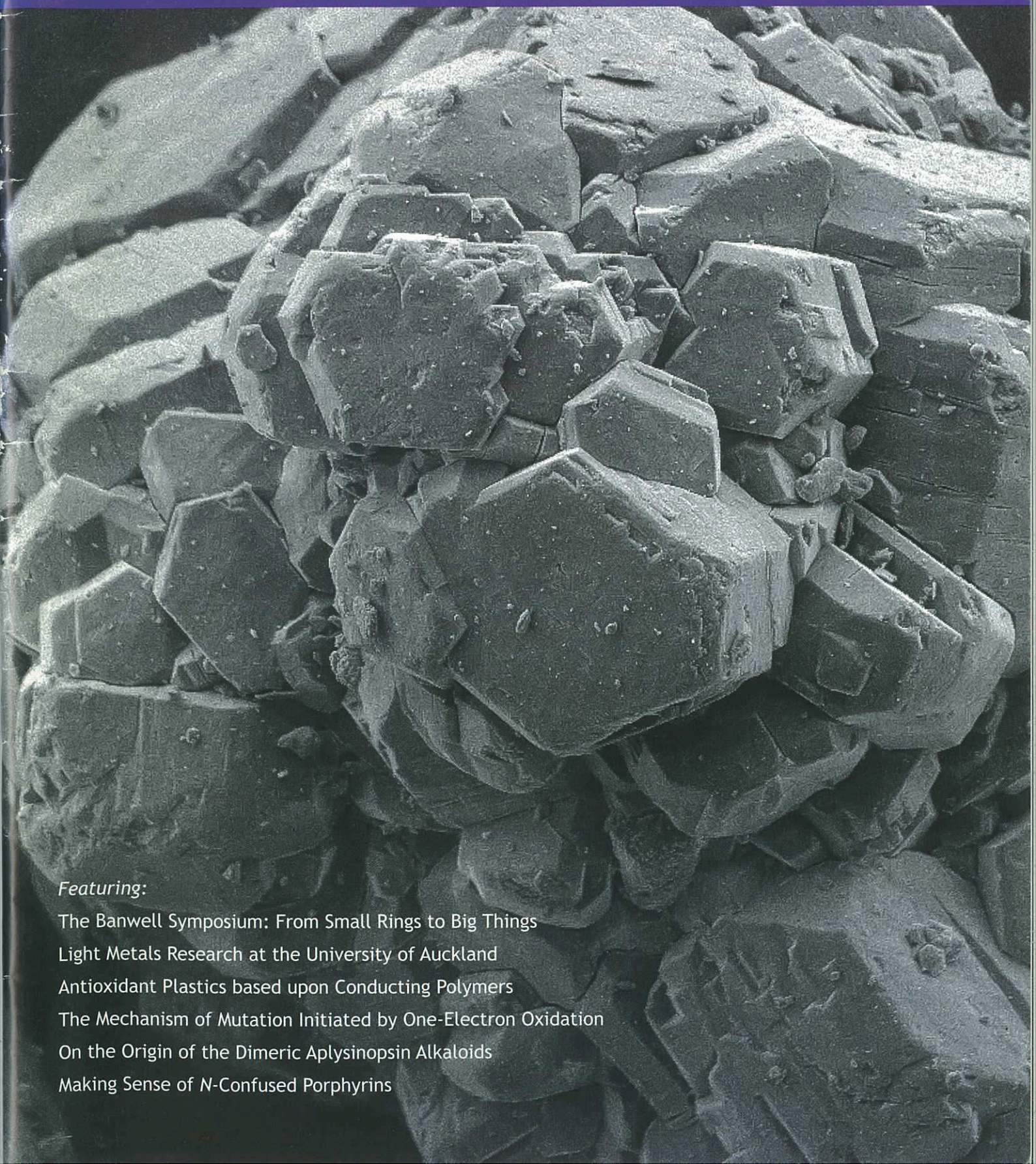

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On the Origin of the Dimeric Aplysinopsin Alkaloids

Making Sense of *N*-Confused Porphyrins

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The New Zealand Institute of Chemistry Incorporated

PO Box 39-112
Harewood, Christchurch 8545

Phone: +64 3 359 7275
Fax: +64 3 359 7248

Email: NZIC.Office@nzic.org.nz

Managing Editors and Publishers

Anthea Lees and Rebecca Hurrell
PO Box 39-112
Harewood, Christchurch 8545
Phone: 03 388 2865
Email: anthea.lees@gmail.com

Scientific Editor

Professor B. Halton, FRSNZ, Hon, FNZIC

Assistant Editor

Dr. A. P. W. Hodder, MRSNZ, FNZIC

School of Chemical and Physical Sciences
Victoria University, PO Box 600, Wellington 6140
Phone: +64 4 463 5954
Fax: +64 4 463 524
Email: brian.halton@vuw.ac.nz *or*
peter.hodder@vuw.ac.nz

Advertising Sales

Anthea Lees
PO Box 39-112
Harewood
Christchurch 8545

Phone: 03 388 2865
Mobile: 021 02522928

Email: anthea.lees@gmail.com

NZIC Chemistry IN NEW ZEALAND

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July News

Comment from the President and ICY 2011

One of the more enjoyable tasks of being President is the opportunity to visit the Branches. I completed the North Island leg of my Presidential tour in May. I would like to thank the Branches for their generous hospitality and also thank all those who spoke with me. I took the opportunity to discuss the details of Council's plans for International Year of Chemistry 2011 that will focus on three major projects. With these projects we hope to maximize media and public exposure, actively involve the members of the Institute and encourage young people to continue to study chemistry. These aims broadly reflect the UNESCO and IUPAC goals for International Year of Chemistry 2011. So what are these projects?

The first project is our launch event. This will take place at the AMN-5 conference (organized by the MacDiarmid Institute) in Wellington in early February. The AMN-5 organizing committee already has plans to incorporate IYC 2011 into their programme and our launch event combines the worlds of chemistry and fashion. At this point I must give credit to Glenda Lewis, who Council has hired as our IYC 2011 consultant. Those of you who know Glenda will be familiar with her work in science media relations, especially with the RSNZ and the MacDiarmid Institute. Glenda's *Chemistry and Fashion* idea involves Jim Johnston's Gold Merino textiles, garments designed by the Massey University School of Design and a show at the Michael Fowler Centre during AMN-5. I think this is an idea that will attract the attention of the media and the general public – the ideal start to IYC 2011.

Our second project is *The Molecular Anthology*. With input from you, our members, a list of molecules, compounds or materials will be compiled that have had an impact on New Zealand. We will then ask for the membership to vote for the top ten (maybe twenty) of these and then compile narratives about the winning molecules. This will provide content for media releases, educational material, and material for the NZIC website. The Manawatu Branch committee is currently working on the details of this.

International Year of CHEMISTRY 2011

The third major project is *The Molecular Imaging Project*. The graphical nature of chemistry and the involvement of chemistry with art in various forms inspired the Wellington Branch to suggest the genesis of this idea, which has subsequently developed into the *Molecular Imaging Project*. For this project we will seek submissions that use chemistry and chemical images as inspiration. The Wellington Branch is driving this project and is now planning how best to activate the ideas.

So we have the basic framework for IYC 2011 in place. I'm really excited about the plans. Of course, the hard work now begins. The International Year of Chemistry is a rare opportunity to promote the benefits of chemistry to society and I am sure that our efforts this year will be justly rewarded in 2011.

All the best,

Mark

Mark Waterland
President

NZIC NEWS

During April and May the Chemistry Education Group ran a series of eight workshops nationwide for secondary school teachers. The workshops entitled *DIY-ICT* were run by Peter Hollamby from the University of Cardiff and attracted 200 teacher participants. The workshops got off to a bad start in Auckland as Peter was grounded in the UK by the Icelandic volcano dust cloud. The Chemical Education group is grateful to *Ian* ***Torrie*** for fronting the Auckland and North Shore workshops in Peter's place. Once Peter arrived the remaining workshops ran as planned and participants went back to their schools armed with a set of four DVDs of resources.

NZIC MEMBERSHIP MATTERS

MNZIC

The Institute is pleased to welcome the following as new members:

Dr *Jack* ***Flanagan*** and Mr *Amir* ***Azi*** (Auckland), Dr *Gareth J.* ***Rowlands*** and Miss *Yogomalar* ***Gnanasegaram*** (Manawatu), Dr *Robert D.* ***Fagerlund*** (Otago), Miss *Katherine* ***Haines*** and Dr *Justin* ***Hodgkiss*** (Wellington), and Prof *Adam Abdul* ***Gafoor*** (Overseas Section).

Student Members

Mr *Brendan D.* ***Harvey*** and Miss *Jacqueline* ***Knobloch*** (Auckland), Mrs *Zhen (Jenny)* ***Jia***, Mr *Ronald H.* ***Marks*** and Mr *David* ***Mills*** (Canterbury), Mr *Emad Mohamed* ***Al-Imarah*** (Manawatu), Mr *Alfred Yiu* ***Chau Tong***, Miss *Trudyanne* ***Goeghegan***, Mr *Ryan E.* ***Hill***, Mr *Raphael* ***Horvath***, Miss *Isobel* ***Maxwell-Cameron***, Mr *Lindon W. K.*

Moodie, Mr *Gregory* ***Rankin*** and Mr *Matthew C.* ***Smart***, (Otago), Ms *Emma* ***Aitken***, Mr *Mark* ***Bartlett***, Mr *Hemi* ***Cumming***, Mr *Alan* ***Dopson***, Mr *Xuyu (Johnny)* ***Liu*** and *Ying* ***Tang*** (Wellington) and Ms *Julia* ***Rinck*** (Overseas Section).

BRANCH NEWS

AUCKLAND

The April NZIC Branch meeting featured a talk given by Dr *Duncan* ***McGillivray*** (Chemistry Department, Auckland) on *Big Science: Research at Large Experimental Facilities*. Duncan outlined research he has been undertaking at the synchrotron X-ray source in Melbourne and the nuclear facility in Sydney. He pointed out the growing opportunities for New Zealanders to undertake research at these centres. In May, Prof *Ken* ***Ghiggino*** (University of Melbourne) spoke at a Branch meeting on *Mimicking Photosynthesis* and the development of materials for light-energy conversion and the dynamics of light harvesting.

Massey University-Albany

Two research seminars were presented at the Albany campus towards the end of March. Dr *Doreen* ***Mollenhauer*** (Freie Universität Berlin) spoke on *Electronic Effects in Multivalent Interactions – From Gold Pyridine Complexes to Larger Systems*, including the use of quantum-mechanical methods for describing the interaction of pyridines with single gold atoms through to gold nanoparticles. Prof *Hans-Beat* ***Buerg*** (Bern University) presented on *The Dynamics of Molecules in Crystals*, in which a diffractometer is effectively used as an infrared spectrometer to provide dynamic information on chemical systems.

Michael ***Wormit*** arrived in May to take up a von Humboldt two-year Feodor-Lynen postdoctoral. He is working on excited states of solid state systems, an extension of his previous research on the accurate description of excited states in molecules. After six years at Massey University's Centre for Theoretical Chemistry and Physics, *Matthias* ***Lein*** leaves in August to take up a new position at the School of Chemical and Physical Sciences at Victoria University where he will establish a new research group in Theoretical Chemistry. *John* ***Harrison*** recently returned from Stanford University where he collaborated with 2010 Priestley Medalist, *Richard* ***Zare***. They can be seen in a *C&E News* picture (2010, *No.12*, 17). *Al* ***Nielson*** is going on sabbatical leave to Oxford.

University of Auckland

In March the single crystal X-ray diffractometer moved from its location on the 4th floor to the new basement laboratory, and the entire X-ray diffraction facility is now functional in its new site across the hall from the NMR suite. The basement area is now very active with several instrumental facilities now in the one place.

Practice for the *Chemistry Olympiad* camp went into full operation in April with support provided by Drs *David* ***Salter*** and *Katrina* ***Graaf***, and further laboratory staff. The Department has hosted a visitor, *Tsuyoshi* ***Shimada*** from Waseda University. Visiting overseas in April was HoD Prof *Jim* Metson, firstly to the National University of Singapore and then on to the University of Qatar and aluminium smelters in the Middle East. Jim gave lectures to classes of engineering undergraduates at the University of Qatar, but had some delays in travelling out of Dubai at that time. More severe delays were experienced by Prof *David* ***Williams*** on an annual research visit to Dublin. The effects of Eyjafjallajokull saw David stranded in Ireland for several days. For the benefit of the Department, the recent seminar that Dr *Johannes* ***Reynisson***, presented on *Benchmarking in Drug Discovery*, started with a group lesson on the correct pronunciation of the Icelandic volcano responsible for the travel delays, along with further Icelandic family names – the breakdown of drug targets into their classes was equally interesting but easier to pronounce!

On a more sporty theme, PhD student *Marsilea* ***Booth*** completed the 100 km *Oxfam Trail Walker Challenge* in April, supported by a team given the appropriate name of *We just popped out for the paper*. It was completed in 24 h 35 min. Food Science MSc student *Yi-Chern* ***Lee*** was also winner of two Gold Medals for table tennis (men's singles and doubles) at the recent Uni Games held in Invercargill.

Recognition of the high standard and increased output of PhD research work within the Department came at the time of the May graduation ceremonies, when 20 eligible PhD theses from 2009 were considered for the L H Briggs Memorial Prize. *Amelia* ***Albrett*** and *Sarah* ***Carley*** were jointly awarded the prize for the best doctoral thesis presented in the Department in the preceding year. PhD student *Greg* ***Hung*** is also deserving of congratulations for winning a *highly commended* prize at the Maurice Wilkins Centre poster competition held on the April 22nd. His poster was entitled *Synthesis of the Cyclic Antimicrobial Peptide/Xenematide*. The second annual Chemistry Research Showcase took place on 9 June, and featured talks by *Norizah* ***Abdul Rahman***, *Lauren* ***Ferguson***, *Catrin* ***Guenther***, *Philip* ***McGill***, *Elizabeth* ***McKenzie***, *Claire* ***Rye***, *Zoe* ***Wilson*** and *Tsz Ying* ***Yuen***.

On the appointments front, Dr *Yacine* ***Hemar***, a Senior Scientist at Food & Nutrition Sciences of the CSIRO in Australia, is due to start work in the Department as a new Associate Professor within the Food Science programme. Yacine presented a seminar in the Department on *Simple Physicochemical Approaches to Complex Problems of Food Science*, and outlined research that includes the application of novel processing technologies (High Hydrostatic Pressure, Pulsed Electric Field and Ultrasound) to the physicochemical properties of proteins and polysaccharides. Congratulations are also due to Prof *Margaret* ***Brimble*** as the winner of the Royal Society of Chemistry Natural Products Chemistry Award for *her outstanding contribution to the synthesis of biologically active natural products, their derivatives and analogues*.

Further Departmental seminars in recent months have included Prof *Peter* ***Scott*** (Warrick University) on *Stereogenic Metal Centres and the Mechanisms of Hydroamination*; *and* Dr *Alexander* ***Tuerke*** (a six month

visitor from the Department of Macromolecular Chemistry, Technische Universität Dresden) on the *Synthesis and Characterization of Silver Hybrid Particles for Ink Jet Printing of Conductive Tracks*, which had been the focus of his PhD studies in Germany. Another research visitor to the *Polymer Electronics Research Centre* at Auckland, A/Prof *Jin-Heong* ***Yim*** (Kongju National University, Korea) provided an overview of research underway with his group at the Nanofunctional Polymer Laboratory, including micelle-templated silica and hydroformylation catalysts, along with highly transparent forms of the conducting polymer PEDOT, and micropatterning using ink-jet printing. In March seminars were also presented by Dr *Helen* ***Hailes*** (UC-London) on *Biocatalytic Synthesis of Ketodiols and Aminodiols* using novel transketolases to effect the chiral conversions; Dr *Shaun* ***Hendy*** (IRL, Lower Hutt) on *Atomistic and Multiscale Materials Modelling*, with a focus on nanostructures formed at surfaces, and the wettability of switchable surfaces; and Dr *Derek* ***Reynolds*** (Reytek Ltd. UK) spoke on *Computational Models for Drug Discovery*, and the important role of lipophilicity within medicinal chemistry.

CANTERBURY

The NZIC BBQ was held in mid-March for the 2nd, 3rd and 4th year and postgraduate Christchurch Chemistry students and NZIC members at the University Staff Club. It was a well attended event.

CPIT

In mid-May twenty six teams of Year 12 students from twenty schools around Christchurch competed against each other at the Christchurch Polytechnic Institute of Technology's Chemistry Competition. Sponsored by the Branch, it saw students carrying out a range of practical exercises including chemical identification of unknown compounds and creation of models of enantiomers. At the end of the evening the top team was from Riccarton High School with an impressive score of 197 out of 200. In second and third place were Middleton Grange School and Cashmere High School, respectively.

University of Canterbury

The civil union of *Ian* ***Shaw*** and *David* ***Zehms*** took place on the weekend of February 13th at their scenic property in Teddington. A good time was had by all and the Department wishes Ian and David a happy future together.

Recent Erskine visitors to Canterbury have included Prof *Vickie* ***McKee*** (Loughborough University) who was here mid-April until mid-June. Her research interests in the application of coordination and structural chemistry across areas ranging from bioinorganic and supramolecular to solid state chemistry were aired in her seminar *Double template effects – mechanism and manipulation* on May 17th. Dr *Paul* ***Wyatt*** (Bristol University) is also visiting the Department as an Erskine Fellow. He completed his PhD at Cambridge and has research interests in asymmetric organic chemistry. He gave a seminar on May 20th, *teaching innovations – using technology to enrich the traditional*, that detailed some of the practical changes that have been made in Bristol chemistry including online resources that make full use of animated and interactive e-learning.

Other visitors have included *Richard* ***Johari James***, a PhD candidate from Pharmacy at UiTM Malaysia whose research interests revolve around drug discoveries for brain related diseases. Richard is working on the BACE1 pathway which is involved in the production of β-amaloid, a hallmark protein in the development of Alzheimer's disease. His UC hosts are *Murray* ***Munro*** and *John* ***Blunt*** (Chemistry) and Tony Cole (Biological Sciences). *Clément* ***Roux***, originally from France, is at UC completing a post-doctorate in *Alison* ***Downard***'s group. His work centres on the preparation of smart switchable surfaces, a project funded by the MacDiarmid Institute. Prof *George H* ***Lorimer***, FRS, (Maryland, USA) was with the Department until early June and gave a seminar on March 1 entitled *The GroELS nanomachine: a biological simulated annealing machine for optimizing protein folding*, a biological example of a simulated annealing device that optimizes the yield of the biologically active native states of target proteins. He was working in Biology and Chemistry. Prof *Wolfgang* ***Schuhmann*** (Ruhr-Universität Bochum), gave a seminar *Modified carbon nanotubes as materials for biosensors and biofuel cells* on March 15. Prof *Richard S.* ***Moog*** (Franklin & Marshall College, PA) gave a seminar on March 30th entitled, *Process orientated guided inquiry learning (POGIL): A student centered approach to instruction* during his NZIC sponsored NZ visit. POGIL is an approach to instruction in the sciences (and other areas) that is based on research on how students learn. *Timothy J.* ***Wallington***, Ford Motor Company, USA) gave a seminar on *Atmospheric science and sustainable mobility: an industrial perspective* in mid-April. He described progress in reducing the vehicle contribution to local air quality and stratospheric ozone issues and the current challenge posed by climate change. Prof *Lee* ***Sharp*** (Grinnell College, US) gave a seminar on May 6th, in which he described semiconductor materials as chemical sensors and photocatalysts for hydrogen production. His research investigates the use of semiconductor materials for the development of phosphor-based chemical sensors, and the development of cataysts for the photoelectrolysis of water to produce hydrogen using sunlight. Prof *Kenneth* ***Ghiggino*** (University of Melbourne,) gave his RSC-RACI-NZIC lecture on May 24th entitled *mimicking photosynthesis*. He outlined the principles involved in developing materials with appropriate properties for photosynthetic mimics. *Andrew* ***Rudge***, CEO gave an Enterprise seminar entitled *Anthrax detectors – the Veritude story* on May 17th. Andrew was the 2004 MacDiarmid Young Scientist of the Year and he described the Christchurch start-up company Veritude that has developed a hand-held instrument capable of detecting anthrax and other bacterial spores.

Congratulations to *Reuben* ***Jane*** and *James* ***Bull*** who have successfully defended their PhD theses. James has commenced a postdoctorate with *Peter* ***Harland***. Congratulations also

to *Sunita* ***Chamyuang*** who defended her PhD thesis in late March. *Ellen* ***Worthington*** and *Daniel* ***King*** won a competition for first-year students run earlier this year and were each presented with copies of the new first-year chemistry text *Chemistry*[3]. *Emily* ***Parker*** attended the 2010 NZVCC NZ Women in Leadership Programme in late June for women academics who are, or aspire in the future to be, leaders within the tertiary sector. Emily is also to be congratulated on receiving the UC 2010 Teaching Award. *Deb* ***Crittenden*** and *Peter* ***Steel*** made it through to the second round of the Marsden Fund. *Francine* ***Smith*** has received $900 funding from the RSNZ for travel assistance to attend the International Conference on Toxic Cyanobacteria in Istanbul in late August/early September. *Vladimir* ***Golovko*** has gained access to the Australian Synchrotron for the 2010-12 operations cycle. Vladimir's project is: *XPS and NEXAFS study of novel catalysts – support immobilized Au clusters.* Congratulations to *Sam* ***Drew*** who represents UC at the AINSE Winter School on *Applications of Nuclear Techniques at ANSTO* (Lucas Heights) in July. Sam has received full funding to attend the forum.

MANAWATU

Congratulations to *Adrian* ***Jull*** who has been elected to Fellowship of Institute for his outstanding contribution to the profession of chemistry in the field of chemical education. The President presented Adrian with his Fellowship certificate. Adrian is a previous winner of the Dennis Hogan Memorial Prize and has made substantial contributions to chemical education both at secondary and tertiary level. Adrian runs the Institute of Fundamental Sciences outreach programme that involves visits to the campus by Year-10 and Year-12 students from Manawatu, Taranaki, Hawkes Bay and Wairarapa.

On May 19, we were honoured to have Dr *Mark* ***Waterland*** give his Presidential Address. The first part of the talk was about the NZIC plans and aspirations for the *International Year of Chemistry, 2011*, which provides a rare opportunity to promote chemistry to general media and to bring to the attention of the public the many positive impacts that chemistry has on everyday life. The second section of his talk dealt with his very intriguing research entitled *Strongly Absorbing π-π* and Metal-to-Ligand Charge-Transfer States in Novel Ruthenium Dipyrrin Complexes: Probing Ultrafast Dynamics with Resonance Raman Spectroscopy.*

In March of this year Dr *Alan* ***Limmer***, noted soil scientist and wine maker, sold his Stonecroft winery in Hawke's Bay. He started planting grapes in 1982 and was recognised by the Queen for his development of the (now) highly regarded Gimblett Gravels region, seen as a wasteland at that time. He was the first in modern times to produce Syrah, now regarded as the hottest variety in Hawke's Bay, and his Chardonnay and Gewürztraminer also have top reputations.

An NZIC beer tasting evening took place at The Brewer's Apprentice on March 9. Those in attendance were treated to a range of appetizers, a series of short lectures on brewing theory and, more importantly, were provided with a constant supply of beer.

Massey University - IFS

The April/May period saw a number of seminars given to IFS. In April, A/Prof *Scott* ***McIndoe*** (University of Victoria, Canada) gave a talk titled *Mass spectrometry-led catalyst discovery* and *Daryl* ***Rowan*** (Plant & Food Research) spoke at the Te Manawa Museum about *Finding Metabolic Markers of Inflammation.* On May 20, as part of the 2010 RSC Australasian Lectureship we had Prof *Kenneth* ***Ghiggino*** (Melbourne) give a talk about mimicking photosynthesis by developing materials with appropriate properties which would be able to mimic nature's effective way of harvesting light energy.

Dr *Simon* ***Hall*** has replaced Dr *Trevor* ***Kitson*** as Head of the Chemistry. Trevor has taken on a new role as teaching fellow. A new group of students have started postgraduate studies: *Kelsey* ***Mortensen*** is working with Dr *Vyacheslav* ***Filichev*** on fluorescently silent probes, *Kerry* ***Betz-Stablein*** is working with Dr *Paul* ***Plieger*** on making molecular nanomagnetic compounds, *Mathew* ***Price*** and *Mohammeed* ***Alsubei*** are working with Dr *Shane* ***Telfer*** on synthesizing novel zeolitic imidazolate frameworks for potential applications for organocatalysts and MOF growth on conductive surfaces, respectively. *Nick* ***Bent*** is working with Drs Shane Telfer and *Mark* ***Waterland*** on the self-assembly of metallodipyrrin complexes, *Nick* ***Collins*** is working with Drs Vyacheslav Filichev, Mark Waterland and A/ Prof. *Kathryn* ***Stowell*** on SERS dependence and *Oliver* ***Mooney*** is working with Dr Mark Waterland on the structure and dynamics of ionic liquids at interfaces. *Shane* ***Chapman*** is working with Dr *Gareth* ***Newland*** on triazole-based monophosphines for catalysis and *Tom* ***Featonby*** is working with Dr *David* ***Harding*** on chitosan surfactants.

Landcare NZ

Dr *Benny* ***Theng*** attended the *Nano-Formulation 2010* conference in Stockholm in June under funding arrangements from the EU 7th Framework Programme. The conference focus was on research, development and applications of innovative formulation technologies where nanomaterials play an essential role. Benny participated in a round table discussion on *smart and functional materials in formulations: coatings, films and tapes*. In April we said farewell to *Mike* ***Horner*** who has moved to Auckland.

NZP

In March, NZP welcomed Dr *Loretta* ***Crowe*** into the fold; Loretta completed her PhD at the Georgia Institute of Technology in 2006. Since then she has had positions at Massey University, working with *David* ***Officer*** and *Ashton* ***Partridge***, and then at Prepared Foods Ltd. In May, Drs *Selwyn* ***Yorke***, *Ghislaine* ***Cousins*** and *Jennifer* ***Peat*** departed for extended stays at Dextra in Reading (UK). Dextra is a carbohydrate and custom synthesis company that was purchased by NZP in September 2009. While in Reading, Jennifer has been involved with the catalogue side of business.

Catalogue have continued to grow in recent times due to the increasing demand from glycobiology. This has led to strong sales of glycoconjugates and oligosaccharides to university and biotechnology organizations world wide.

OTAGO

The Branch held its annual dinner in May at the new Otago Polytechnic training restaurant, Technique. *Thomas* ***Rades*** from the Pharmacy Department entertained the guests with a lively post-dinner lecture entitled *From Drugs to Medicine.*

University Chemistry Department

After 27 years in the Campbell Microanalytical Laboratory and 32 in the Department, *Marianne* ***Dick*** retired in May. The Department is greatly appreciative of her efforts and hard work through the years as we are sure many of the NZ chemical community are.

Barrie ***Peake*** has had two students recently complete research in his group. *Alfred* ***Tong*** (PGCert: *Direct UV photolysis of aspirin, diclofenac and oseltamivir in aqueous solution*) and *Vida* ***Rowhani*** (MSc: *Environmental aspects of the Cadbury Confectionery Limited (Dunedin) operations*). Alfred has now started a PhD under joint supervision with Rhiannon Braund (Pharmacy), investigating drug disposal practices and the levels of selected pharmaceuticals in NZ waste waters. Another of Barrie's PhD students, *Victor* ***Cubillos*** [with *Miles* ***Lamare*** (Marine Sciences) and *David* ***Burritt*** (Botany)], is completing his study of the seasonal dependence of mycosporine-like amino acids in a range of intertidal organisms around NZ. In February, Barrie gave a seminar on *Trace metal signatures of cardboard* at the Carter Holt Whakatane Mill and at SCION (Rotorua).

Grace Morgan (UC-Dublin) visited during March and Annie Powell (Karlsruhe), a long standing collaborator of *Sally* ***Brooker***'s, visited for a week in March. *Jonathan* ***Kitchen***, a PhD student and then postdoctoral in Sally's group, recently left to take up a two-year Irish Research Council postdoctoral fellowship to work with Thorri Gunnlaugsson (Trinity College Dublin) and *Stephen* ***Faulkner*** (Oxford) on *The development of lanthanide-metal ion directed self-assembly formation of water-soluble dimetallic triple stranded helicates.*

Planning for the 2012 International Symposium on Macrocyclic and Supramolecular Chemistry (ISMSC-12) in Dunedin is well underway – if you haven't already done so, please register your interest via the conference website ***www.otago.ac.nz/ismsc2012/*** to ensure you are on the emailing list for further information.

Two PhD students in *Keith* ***Hunter***'s group, *Katherine* ***Baer*** and *Hugh* ***Doyle***, received NZ Marine Sciences Society travel grants to attend the Ocean Sciences Meeting in Portland, Oregon in February.

A group of students from science communication and from *Kimberly* ***Hageman***'s research group received first runner-up place for their contribution to the Environmental Science and Technology journal's video contest, *How Does Chemistry Help YOU Be Green?* Their video is available for viewing at *www.youtube.com/watch?v=8bsLYLm0pUc or pubs.acs.org/page/esthag/video/contest-winners.html*

Catherine ***Sansom*** is commissioning a new GC-MS in the Plant Extracts Research Unit. This will be used for work on flavours, in native and introduced plants, and Plant & Food Research's work on insect attractants. The unit includes automated solid-phase micro-extraction (SPME) for headspace analyses.

David ***Warren***, *David* ***McMorran***, and a number of students from the Department spent a Sunday in March at Otago Museum's *The Big Get Together* doing chemistry experiments, helping kids make slime and ice cream, and *supervising* people exploring the properties of non-Newtonian fluids in a very large container of custard. The event attracted a large number of people, many of whom stopped to see what was going on and to talk about chemistry and science.

WAIKATO

University of Waikato

The Chemistry Department had a large number of students working over the past summer on diverse research projects, many of whom were recipients of summer research scholarships. Recently, the University held its inaugural *Summer Scholarship Student (SSS) Symposium*, at which all students gave a brief presentation on their research work. It proved to be an enjoyable way for staff and fellow students to find out what it was they had all been up to.

The 2009 undergraduate prizes in Chemistry were awarded recently as follows:

1st year prize (Orica Chemnet Prize) *Connie Hui Jui* ***Kueh*** and *Erica* ***Prentice***

2nd year prize (NZIC-sponsored J. E. Allan Prize) *Ivan* ***Schroder***

3rd year (DOW Agrosciences sponsored prize) *Sam* ***Pachal***

Waikato University 2009 Undergraduate Prize-winners in Chemistry. L-R: Sam Pachal, Ivan Schroder, Erica Prentice and Connie Kueh.

Our congratulations go to *Ho Ying* ***Yuen***, a BSc (Tech.) student in Chemistry who won one of the three poster prizes at the recent Waikato Sustainable Bioeconomy Student Poster Conference. Her work is on beeswax/PEO as a material for controlled release drug delivery in animals. The research was conducted in the Department over the summer on a smmer research scholarship.

Joseph ***Lane*** presented a talk at the ACS Spring Meeting entitled *Explicit correlation and intermolecular interactions*,and also visited Profs Randy Snurr (Northwestern Univer-

opment of the ESI-MS techniques to include neutral compounds, non-polar solvents and MS-MS data, Scott captivated the audience with his insight to new methodology and its application to transition metal catalysed organic reactions. Dr *Emiliano* ***Cortés*** (Theoretical and Applied Physical Chemistry, National University of La Plata, Argentina) was with us in mid-April and described his work on *self-assembled monolayers (SAMs) and nanofabrication methods* that are key elements for many promising applications in this wide field. Thiols are essential in many of the so-called *bottom-up* methods proposed to build a wide variety of devices and materials. On gold they are particularly attractive because they represent an easy path to link inorganic, organic, and biological materials to a stable and chemically inert surface. They are regarded as basic units in molecular electronics, as building blocks in sensing and biorecognition devices, in actuators, molecular motors, and biomimetic phospholipid membranes. The fundamental concepts of thiol and dithiol self-assembled monolayers on metallic surfaces were discussed as well as examples related to molecular electronics and nanofabrication methods. Dr *Paul* ***Wyatt*** (Teaching and Learning, Bristol University and Canterbury Erskine Fellow) met with staff and spoke on *Teaching Innovations - Using Technology to Enrich the Traditional* that included some of the practical changes made in Chemistry at Bristol University. He described how these influenced innovations for the Bristol ChemLabS Centre for Excellence that has on-line resources, which make full use of animated and interactive e-learning to enrich the understanding students have of the practical experience. The e-learning system does not replace the real hands-on practical experience but allows students to take on *more* challenging experiments; a fascinating new innovation.

May 26 saw the visit of the highly distinguished Prof *Susan B.* ***Horwitz*** (Molecular Pharmacology, Albert Einstein College of Medicine, New York City; Associate Director, Therapeutics, Albert Einstein Cancer Center). She has had a continuing interest in natural products as a source of new drugs for the treatment of cancer and her studies of Taxol go back to the early 1970s. It is largely as a result of her work that the National Cancer Institute became interested in its development. She spoke on *Taxol, Tubulin and Tumors* to an audience well excess of 100, enthralled everyone, then was interviewed for the Kim Hill radio programme that aired on May 29. It was an occasion to remember and thanks go to Dr *Peter* ***Northcote*** (SPCS and Centre for Biodiscovery) for attracting this very distinguished speaker and researcher to NZ.

IRL

During April a new Bruker 500 MHz NMR spectrometer was installed on the Gracefield campus to augment the service already provided by the existing 300 and 500 MHz instruments. The two 500 MHz spectrometers become the workhorses for a user friendly, easy to use NMR service for over 30 very active synthetic organic chemists. The deliberate choice of almost identical spectrometers equipped with a 60 sample autochanger provides high throughput, redundancy for interchangeability of modules, and avoids duplication of expensive probes. Moreover, the new spectrometer features Bruker's state of the art liquids *Smart Probe* which combines two probes (Standard Multinuclear and Inverse probes) into one, and provides the commonly used nuclei ^{1}H, ^{13}C,^{31}P, ^{19}F as well as more than 50 other NMR active nuclei, all of them potentially accessible automatically on the fly. Other novel probes include a 1 mm MicroProbe for studying microgram quantities of sample and a range of High Speed Magic Angle Spinning Solids probes that support IRL's programmes in Nanotechnology, Geopolymers, Hydrogen Storage and Advanced Ceramics.

IRL and Epichem Pty Ltd. have announced the launch of a strategic alliance designed to provide clients with continuous and seamless services from drug discovery to cGMP production. Both are viewed as providers of high quality products and services in the area of organic chemistry, and possess complementary skills that will combine to better serve the Australasian pharmaceuticals market (see: *www.epichem.com.au/*).

US biotech company, BioCryst Pharmaceuticals Inc. recently announced the initiation of a Phase 2 human clinical trial of the drug candidate BCX4208. This is for patients suffering from gout, a severe form of arthritis affecting tens of millions of people globally and which is particularly common in Maori and Pacific Island peoples. BCX4208, co-developed by IRL, is a next generation purine nucleoside phosphorylase (PNP) inhibitor, which a recent study shows may have utility in diseases dependent on T-cells, B-cells or uric acid. The latest trial is designed to determine the effect of dose levels of orally administered BCX4208 on uric acid levels in the blood, the build-up of which can lead to the often painful condition known as gout.

March saw the era ended with the retirement of IRL glassblower *Keith* ***Holden***. Keith has been replaced on a part-time basis by *Grant* ***Franklin***, the VUW glassblower. *Jeremy* ***Wu*** recently attended the International Conference On Nanoscience and Nanotechnology (Sydney) and presented a talk on *template assisted growth of nanowires by anodic alumina*. This was followed by a four-week BRAP-sponsored visit to the Industrial Technology Research Institute in Taiwan, where he worked in the Energy & Environment laboratories. The IRL Materials & Energy team has established a process for fabricating thin ceramic templates with highly uniform, tuneable nanoporous channels. These porous anodic alumina (PAA) templates are amorphous and thermally stable up to 800 °C.

Robert ***Holt*** is working with colleagues at IRL-Christchurch to develop an oxygen generator for the Coal Research Laboratory lignite-biomass gasifier. A wind-powered electrolyser (based upon the IRL design) offers a scheme to generate future fuels that are nearly carbon neutral and that can potential exploit a major NZ resource, namely lignite.

Tim ***Kemmitt*** is busy organising the early 2011 MacDiarmid Institute *Advanced Materials and Nanotechnology* conference (AMN-5). This will

be held in Wellington 7-11 February next (see *www.macdiarmid.ac.nz/amn-5/*) for further details. His PhD student *Kathryn* ***Graham*** spent a couple of months overseas, firstly at the Pacific Northwest National Laboratory (Washington State) to carry out some synthesis and high field solid state NMR studies of native and deuterated versions of methyl ammonium borohydride containing all ^{11}B. The samples are then to be transferred to Oxford, where she will carry out neutron beam experiments at the Rutherford Appleton Laboratory to examine various aspects of structural and chemical interest. The project has some relevance to hydrogen storage applications, although it is aimed primarily at studying some fascinating chemistry. New MSc student *Rachael* ***Linklater*** is studying the factors controlling the incorporation of Al doping in ZnO sol-gel films, controlling film texturing and alignment, and optimising conductivity. The project is aimed at making transparent conductive films for photovoltaic applications. Finally, Tim is completing a joint NIWA/IRL/JamesCookUni project to use photocatalysis for marine antifouling that is showing great promise. This will renew his interest in photocatalysis after some years of low key involvement following his pioneering work in the 1990s.

Neil ***Milestone*** has returned to NZ after seven years at the University of Sheffield where he was Director of the Immobilisation Science Laboratory. Much of his work there involved the use of cements for waste stabilization and in gaining an understanding of the reactions that occur between cements and various types of wastes, including nuclear materials. He is now working with *Carl* ***Bigley*** at IRLs Cementing Systems research unit investigating reactions used in geothermal applications for cementing steam wells.

The Banwell Symposium: From Small Rings to Big Things

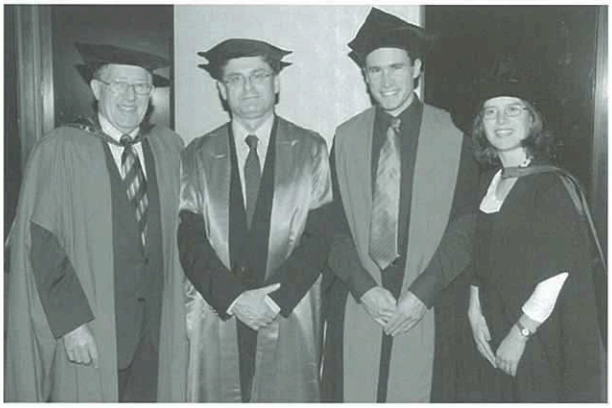
Russell J. Hewitt and Robert A. Keyzers

School of Chemical & Physical Sciences, Victoria University, PO Box 600, Wellington 6140
(e-mail: *rob.keyzers@vuw.ac.nz*)

May 18, 2010 was a particularly significant day in the annals of Victoria University of Wellington (VUW) and its division of chemistry. The day marked the graduation ceremony at which Prof. Martin Banwell [Director of the Research School of Chemistry (RSC) at the Australian National University (ANU)], was awarded the degree of Doctor of Science, *honoris causa* by the University. Prof. Banwell has an outstanding research record that has led to his recognition as one of the greatest organic chemists in the Southern Hemisphere, further exemplified by VUW judging him worthy of an honorary DSc after only 31 years since obtaining his PhD from the same institution.

The significance of this ceremony was not only due to Prof. Banwell's award but also for the multiple generations of related chemists present. Emeritus Professor Brian Halton, Prof. Banwell's VUW PhD supervisor was on-stage as was Dr. Joanne Harvey, a VUW graduate, now staff member and former ANU PhD student of Banwell's. Finally, Mr. Russell Hewitt, a student of Dr. Harvey's, had his PhD conferred at the same ceremony. Consequently, four generations of PhD researchers of the Halton Dynasty were on-stage at once, with two having doctoral degrees conferred in the same ceremony. Moreover, all four generations have made significant contributions to the same area of chemistry, namely, the formation and practical application of fused cyclopropane ring systems. This gathering of four generations of chemists, of which two were awarded doctorates, is believed to be unprecedented in New Zealand chemical history.

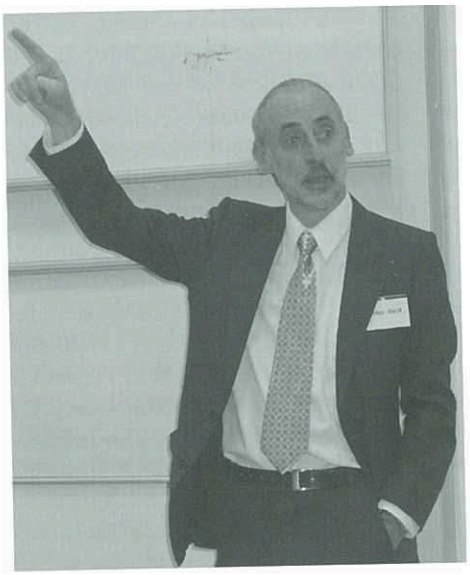
In recognition of Prof. Banwell's remarkable achievements and to celebrate his award of his Hon. DSc, the School of Chemical and Physical Sciences (SPCS) at VUW held a symposium entitled *From Small Rings to Big Things* on May 20 May in his honour. This symposium marked another noteworthy day, as the meeting was the first official function hosted by SCPS in the new Alan MacDiarmid Building, a multi-million dollar investment for Science and Engineering, named after VUW's 2000 Nobel Laureate. The Banwell Symposium showcased the excellent teaching and research facilities now available to the school.



From left: Professors Brian Halton and Martin Banwell, Drs Russell Hewitt and Joanne Harvey. Photography by Woolf.

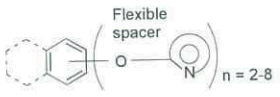
The symposium itself was opened by fellow chemist and Dean of Science, Prof. David Bibby, who described Martin Banwell as the *...most outstanding chemist of his generation in Australasia* and it was obvious to all just how much of a pleasure this gave the Dean. The symposium included local speakers from VUW and Industrial Research Limited (IRL) with invited lectures from by Profs. Peter Steel (Canterbury University) and Martin Banwell.

The day's event focused on organic chemistry in the broadest possible sense as a wide range of topics was



Professor Peter Steel

covered. Prof. Steel began the presentations with an enthralling lecture entitled *The Power of Weak Interactions in Constructing New Metallosupramolecular Assemblies*, in which the syntheses of such assemblies from various metals and ligands was shown to give a wide range of geometrical structures. Peter spoke about the ability to construct desired geometries by using different metal centres coupled with ligands containing specific binding angles within flexible spacer groups as depicted by **1**. Typically, these were obtained by coupling bisphenols to nitrogen heterocycles. He also described the specific use of π-π, Ag-Ag or Ag-alkene interactions in the construction of the different metal complexes. Peter first met Martin at Canterbury University when he (Martin) went to Christchurch to record some ^{13}C NMR spectra in their facility, the only one available at the time. Since then they have had the opportunity to meet many times, with Banwell describing Steel as a magnificent host during his Erskine Fellowship - even though Peter was distracted from his duties when Bob Grubbs, also an Erskine Fellow, was advised of his receipt of the 2005 Nobel Prize in Chemistry.



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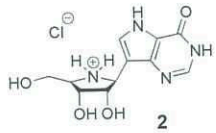

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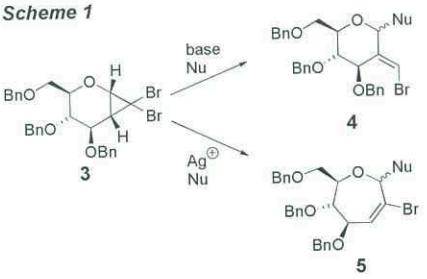
Another former Halton PhD student, Andy Kay of IRL, gave a fascinating discourse on his team's work to produce new chromophoric molecules that can be used in non-linear optics. In particular, he described the photophysics of such materials and the fundamental results they have generated by optimizing *right-hand side* chromophores, a niche area of such research, which may find use in optical data transmission (see *This Journal*, **2010**, *74*, 72).

Both Richard Furneaux (IRL) and Mattie Timmer (VUW) gave interesting accounts of the syntheses of aza-sugars that have been produced for the treatment of specific diseases. Furneaux's team, in collaboration with Schramm (Albert Einstein College of Medicine, New York) have developed drugs such as Forodesine (Immucillin-H) **2**, which mimic the transition state during an enzymatic transformation, rather than the actual substrate, which leads to permanent inhibition. Forodesine analogue, BCX-4208 is in clinical trials to treat gout and is a potent inhibitor (K_i = 16 pm) of Purine Nucleoside Phosphorylase (PNP).

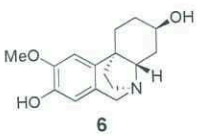
The Timmer/Stocker group, on the other hand, have developed a protecting-group free strategy for the synthesis of aza-sugars. This talk, *Synthesis of Aza-Sugars* contained their latest results towards a combined Vasella reductive amination/carbamate annulation strategy for the formation of a variety of aza-sugars (see: *This Journal*, **2010**, *74*, 57). The seminar also presented the latest attempts to probe the probable mechanism at play in the formation of these important drug leads, which may act as glycosidase inhibitors.

The newly graduated Dr. Russell Hewitt described part of his PhD research, a fascinating introduction into the use of cyclopropanated carbohydrates. He focused on his correction of the ring-opening product of cyclopropanated carbohydrate **3** as C-2 substituted **4** and not the seven-membered oxepine **5**. (Scheme 1) He also demonstrated how the desired oxepine **5** can be formed from use of suitable silver salts.

Scheme 1



Joanne Harvey then presented an insightful and detailed account of two natural product syntheses using *gem*-dihalocyclopropanes. The first concerned the synthesis of maritinamine **6** during her doctoral studies, a target whose similarity in its name to that of her supervisor was but incidental. The second part described an attempt to synthesize the fungal natural product (-)-TAN-2482B **7**. Although unsuccessful in making **7**, the Harvey team came tantalizingly close and are confident that they will complete the total synthesis of this challenging target in the near future.



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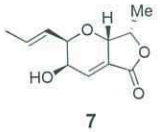

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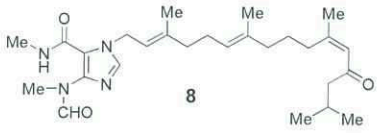
Two natural products seminars were also presented, the first by recently appointed VUW academic Rob Keyzers. He described postdoctoral work involving the isolation and structural elucidation of the tetraprenyl alkaloid malonganenone B, **8**. Keyzers then went on to discuss his group's work focused upon the synthesis of analogues of **8** that are designed to explore novel H/D exchange within the natural product. In an entertaining discussion, Dr. Peter Northcote described in detail his group's methodology, historical and on-going, to use NMR spectroscopy

to guide the isolation of natural products. The work dates from the late 1990s and has evolved from simple ^{1}H NMR spectral analysis of sponge extracts to comprehensive 2D-NMR-based screening using sophisticated in-house software for spectral manipulation.



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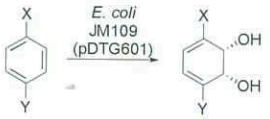
9 **10**

The final session of the day, purposefully chaired by Russell Hewitt, saw Halton himself provide a *...hysterical/historical account...* of Martin's time in the laboratory during his research days at VUW. One point Brian noted was that Martin's PhD research to synthesize angular **9** and linear **10** bis-cyclopropanes was *...singularly unsuccessful...* in its aim, yet produced some wonderful results. Martin's great enthusiasm during this time was a sure indicator of his future success; few PhD students submit and defend their thesis, and then depart for a postdoctoral fellowship within 30 months! Brian also highlighted the difficulties in ordering chemicals during that era - orders could only be put through once or twice a year. Today's younger generation tend to purchase anything listed in the Aldrich catalogue if needed, whereas Brian stated *if the chemical was in the Aldrich Catalogue then it could be made!*. Martin replied *that was the curse of the Aldrich Catalogue. If it was in the catalogue you could make it, and if it's not there then you HAD to make it!*

Dr Russell Hewitt

Martin then provided the final seminar of the day entitled *Chemoenzymatic Methods for the Assembly of Biologically Active Natural Products*. Through use of an enzymatic asymmetric dihydroxylation process, Banwell has shown that the *cis*-1,2-dihydrocatechol products obtained, *e.g.* **12** from **11**, are versatile intermediates for the synthesis of various alkaloids. His group has utilized the enantiospecific formation of the catechols in a number of total syntheses of natural products including (-)-panepophenanthrin. Moreover, Martin presented several insightful strategies to take the single enantiomer of the catechol produced and use an enantiomeric switching technique to make natural products with each possible absolute configuration, a wonderful feat. Once again the seminar highlighted Martin's inspiring and elegant synthetic ventures incorporating the total synthesis of a very impressive number of natural products, providing a magnificent *tour de force*.



11 **12**

Student posters were also presented throughout the day that showcased the variety and quality of VUW research. Profs. Banwell and Steel awarded the Dean's prize to Mark Bartlett for his poster *A Novel Palladium-Catalysed Allylic Alkylation Cascade for the Synthesis of Furanopyrones* from his first year of doctoral research.

The day concluded with drinks and a symposium dinner in the staff club where SCPS Head Prof. John Spencer presented Martin with a commemorative bound copy of the symposium programme.

Professor Martin Banwell

Martin Banwell has made enormous contributions to chemistry with over 260 papers, patents and book chapters that describe chemical methods and syntheses at the forefront of modern organic research. As director of ANUs RSC, he heads the most prominent school of chemical research in the southern hemisphere. He maintains one of the more productive research groups in natural product synthesis and has supervised over 100 graduate students. He is an Honorary Fellow of the Royal Society of New Zealand, a fellow of the Australian Academy of Science and a Fellow of Royal Australian Chemical Institute. His honorary doctorate exemplifies his impact as a research chemist, and he remains an inspirational figure to younger chemists.

Article

Light Metals Research at the University of Auckland

J. Metson, P. Lavoie, L. Perander and R. Etzion

Light Metals Research Centre, University of Auckland, Private Bag 92019, Auckland 1142
(e-mail: *j.metson@auckland.ac.nz*)

Introduction

The Light Metals Research Centre (LMRC) at the University of Auckland was founded in 2002 and followed some twelve years of research in aluminium, titanium and magnesium largely in Engineering led by Profs. Barry Welch and John Chen. Their activity expanded significantly through the 1990s with the involvement of Margaret Hyland and Jim Metson. Following Welch's retirement, a cross-faculty research centre was formed under the interim directorship of Jim Metson and taken over by Mark Taylor when he joined the University in 2003. The Centre was established with the objective of providing world-leading expertise with a full suite of research and development capabilities, and training and education for the global light metals sector. The Centre is located largely within Chemistry, but the emphasis on external (and particularly international) contract research means activities are managed through Auckland Uniservices Ltd., wholly owned by the University of Auckland.

Although both the Bayer process for alumina refining and the Hall-Heroult process for electrolytic reduction are more than a century old, both face major challenges in an increasingly energy- and carbon-constrained world. There are ongoing issues in materials science, process control, energy recovery and reduced environmental impacts that are increasingly part of the industry's viability and licence to operate. Herein, the contributions of the Centre in addressing two particular chemistry-themed challenges encountered in the aluminium production chain are presented. The first case study describes how advanced characterization techniques give insights on how calcination technology affects the phase transformation reactions and phase distribution in smelter-grade aluminas; the second addresses the understanding of the corrosion mechanisms of silicon carbide sidewall refractories, critical to the life of the reduction cell.

Light Metals Research Centre

The LMRC currently employs around 30 research professionals, mostly engineers with some chemists and physicists, and hosts 12 postgraduate students. Some 20 academics from fields that include chemistry, mathematics, industrial psychology, and multiple engineering fields also contribute to the research programmes operating within the Centre. The LMRC is currently engaged in over 40 such projects with 20 industrial, 13 University and 7 Governmental agency partners spanning 15 countries. These projects range from fundamental research to commercialization of industrial technologies, and cover the major industrial growth areas such as in China and the Middle East. Additionally, smelter innovations in older plants are driven by the need to accommodate a changing energy market. Aluminium smelting technology, including alumina production and the environmental impacts of the industry, is by far the largest part of the research undertaken, with projects also in areas such as titanium processing, magnesium alloy development and surface treatment.

Technical consultancy and research contract services provided through the Centre are supported by research in process fundamentals, aligned with experience in materials science, process control, operations management and scientific method-based process improvement. The Centre also offers tailored industrial training courses and postgraduate qualifications from the University. Long-term research in material science and engineering has made the LMRC into a world leader in Al industry, industrial materials, and process development. For example, it has developed standard quality tests for electrode and refractory materials where chemical and electrochemical corrosion can be tested. Coupled with advanced material characterization methods, they give insights into complex corrosion mechanisms and help in the design of materials with properties better suited to their operating environment.

The LMRC has also been developing and commercializing its own technologies. An example is the Sidewall Heat Exchanger (SHE), a compact and efficient air-driven heat exchanger capable of providing controlled cooling of smelter cell sidewalls. The SHEs enable increased amperage to the reduction cell and the ability to accommodate power modulation, while retaining other operational benefits, including a cooler operating cell and ultimately allowing waste heat recovery of 100-200 kW per cell.

The Microstructure of Metallurgical Grade Aluminas

The Hall-Heroult process produces aluminium metal by electrolysis of alumina (Al_2O_3) dissolved in molten cryolite (Na_3AlF_6). For every tonne of primary metal, 1.92 tonnes of alumina are required. Thus, the tonnage of alumina produced rises at approximately twice the rate of growth in metal production. Primary metal production sits at about 40 M tons annually and typically shows *ca.* 3-4% year on year growth.[1] It is worth noting that secondary (recycled) production has grown considerably faster than primary and, since around 2004, has exceeded the production of primary metal.

Around 90 M tonnes of alumina are produced annually, 95% of which is destined for aluminium smelting.[2,3] The balance is produced primarily for catalysis, refractories and abrasives markets. The largest refineries now produce between 4 and 7 M tonnes of alumina annually. The distribution of the scientific literature on alumina is almost the inverse of this and is dominated by applications in catalysis, and (increasingly) the synthesis alumina in a range of exotic morphologies extending to the nanoscale.

However, the microstructure and properties of metallurgical or smelter grade aluminas (MGAs) are of considerable interest, primarily because of the relationship to alumina refinery operation and in their impacts on the smelting process.

Alumina is produced in the Bayer process by the digestion of bauxite, the precipitation of Gibbsite [$Al(OH)_3$] from a clarified sodium aluminate solution, and calcination to produce the alumina.[4] An electron micrograph of a *typical* Bayer process alumina particle resulting from this process is shown in Fig. 1. The aggregated particle morphology and texture reflect the seeding strategy and precipitation conditions, typical for a Bayer plant, where agglomeration is a faster mechanism of particle growth than the growth of individual crystals.

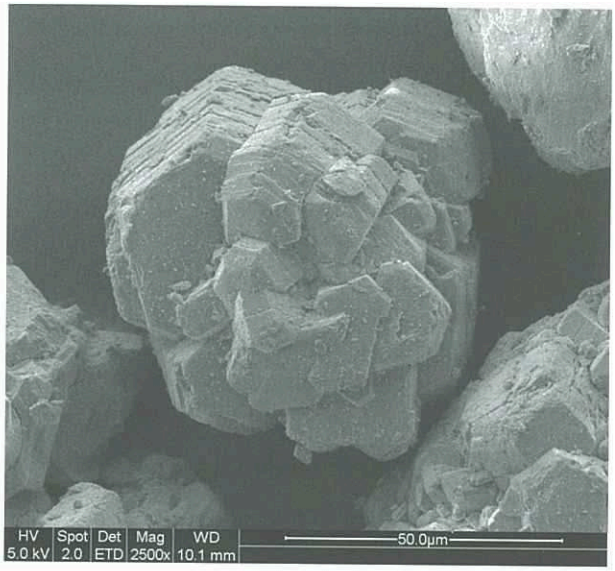


Fig. 1. SEM image of a *typical* Smelter Grade Alumina grain.

Charge contrast in the Environmental Scanning Electron Microscope (ESEM), or variable pressure SEM, has been shown to be a useful tool in studying gibbsite and alumina microstructure.[5,6] Previously, the technique has been used to study Gibbsite growth characteristics as slight variations in structure owing to defects and impurities; these result in a contrast difference observable in particle cross sections.[6] More recent approaches have revealed further internal and structural features that can be related to crystal growth mechanisms. Compositional variations arise from the cycling of growing crystals through precipitation tanks that have a varying Al:Na ratio as the Al is depleted by gibbsite precipitation. Fig. 2 shows a gibbsite cross section where these growth rings are visible through such charge contrast techniques.

Calcination transforms Gibbsite into a range of predominantly transition aluminas (Fig. 3) with the pathway across this phase *roadmap* and makeup of the final product, dependent on calciner technology.[7,8] This technology has progressively moved from rotary kilns to more energy efficient gas suspension or circulating fluidized bed processes, in some cases with capacity in excess of 4,000 tonnes per day. Energy consumption is now typically below 3 MJ/kg in such stationary calciners, within about 20% of the theoretical minimum for the calcination of a

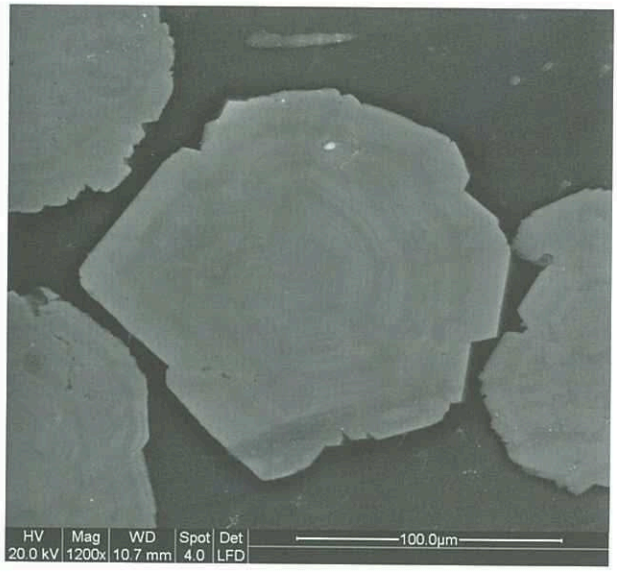


Fig. 2. Charge contrast differences in gibbsite.

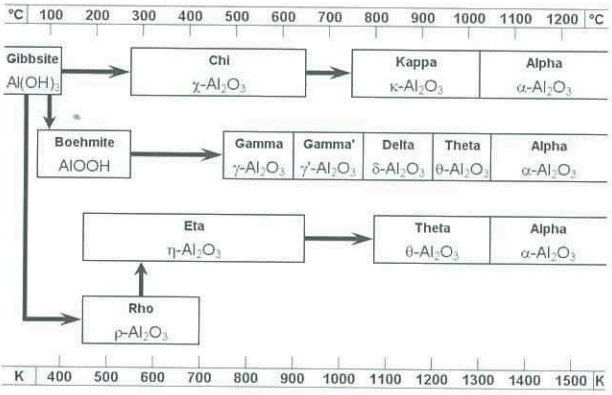


Fig. 3. Gibbsite calcination pathways (adapted from Wefers, *et al.* – see ref.9).

moist Gibbsite. However, contact times between particles and gases at temperatures of up to 1000 °C in the hot zone may be as short as a few seconds; thus, rapid heat transfer into the particle is critical in achieving conversion to alumina. Transformation of gibbsite to the transition aluminas is pseudomorphic, with the original crystal habits, the external dimensions and the morphology largely retained, even though a series of crystallographic phase changes occur. As a consequence, significant porosity develops during the initial heating stages.[9]

The presence of this porosity and the dominance of transition aluminas is key both to the use of the alumina as a medium for dry-scrubbing of cell gases,[10] and in effective dissolution of the alumina in the electrolyte. Before feeding to the reduction cell, alumina is used as the primary medium for cell gas scrubbing. Specific surface areas between 70 and 80 m^2/g typically are specified to accommodate scrubber needs.

X-ray diffraction-based structural phase analysis of the MGAs is especially challenging owing to the presence of these metastable, sub-crystalline, transition alumina phases. The gibbsite transformation pathways are often (mis)represented by diagrams such as Fig. 3. The distinction between the transition alumina phases, or forms,

is not as well defined as the diagram might imply. It is generally agreed that θ-alumina is more ordered than δ-alumina, which again is more ordered than the γ-alumina phase.[11-13] However, exactly how the transformation into the more ordered forms proceed is still the subject of debate.[9,14,15] The formation of γ-, γ'-, and θ-alumina can be seen as waypoints on the gradual transformation into the fully ordered state represented by α-alumina.

A typical X-ray diffraction pattern collected at the Australian Synchrotron for an alumina from fluid bed (CFB) calcination is shown in Fig. 4. For several reasons in wavelength selection and intensity, the synchrotron provides a substantial advantage in data quality for these difficult samples. At the LMRC, the Rietveld refinement approach has been developed to build an SGA model based on the γ-, γ'-, θ-, and α-phases, to allow a quantitative phase analysis.[16] The transition aluminas are modelled based upon literature data for these defect cubic spinel structures, with varying occupancies of the octahedral and tetrahedral aluminium sites. This approach still recognizes that although such a quantitative phase analysis can never be absolutely correct because of the arbitrary boundaries between phases, it can be self-consistent. This has provided a valuable tool in the comparison of aluminas and, in particular, the impacts of calciner technologies and in understanding their behaviour in the smelter.

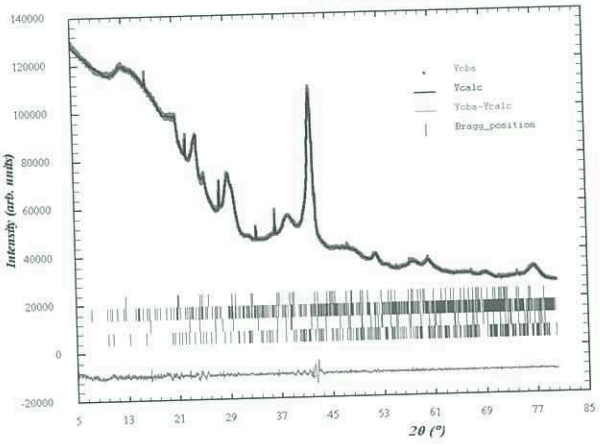


Fig. 4. Synchrotron X-ray powder diffraction pattern of a CFB calcined MGA sample and resulting Rietveld refinement results; the sloping background is a result of the amorphous nature of the quartz capillary used for sample mounting.

The central problem in the short length scale of ordering in these materials has prompted several more novel approaches to address this structural analysis question. We have made considerable use of high field ^{27}Al MAS SS NMR, X-ray Absorption Spectroscopy (XAS) and Atomic Pair Distribution Functions (PDF) derived from neutron diffraction data, in examining the structural relationships within these materials.[17-19] These methods allow an examination of the local chemical environment without the need for crystallographic long-range order. Access to high field SS NMR facilities in the UK, and Synchrotron and Neutron Facilities in Australia and the USA has been central to these studies.

Fig. 5 illustrates data from the soft x-ray line at the Australian Synchrotron, where the near edge X-ray absorption (XANES) spectrum has been used to probe site occupancy in these materials. It can be seen that resonances characteristic of alpha alumina are present in the industrially calcined samples. Similarly, features related to aluminium in tetrahedral oxygen coordination are also visible in the SGAs. Although useful as a fingerprinting tool for SGA, quantitative analysis of this data is challenging due to the complex multiple scattering interactions in the sample.

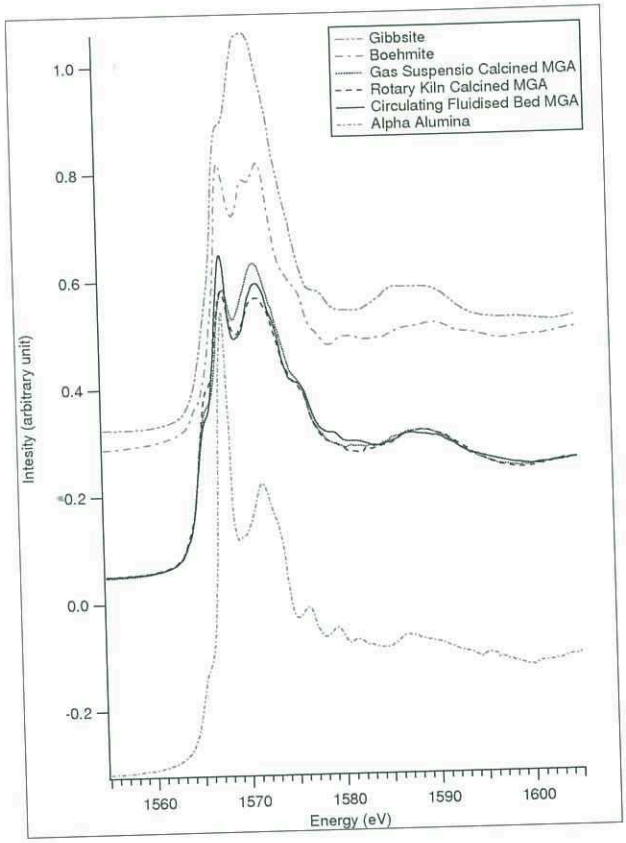


Fig. 5. Al K-edge XANES spectra from a selection of aluminas typical of several calcination technologies, the gibbsite starting material, the oxyhydroxide boehmite, and fully calcined α-alumina (bottom).

An interesting consequence of the rapid heat transfer into particles is the phase differences observed within grains in addition to that between grains. This is beautifully illustrated in the charge contrast ESEM images in Fig. 6, where the lighter coloured surface layer shows evidence of almost complete conversion into α-alumina, while the interior retains the transition alumina structures. The phase assignments associated with the contrast in the images have been confirmed with TEM electron diffraction studies on sectioned samples.[7] The structure seen in Fig. 6 is expected to have significant impacts on the dissolution behaviour of the alumina when fed to the reduction cell. α-Alumina is known to have poor dissolution characteristics and often sinks to the bottom of the reduction cell, forming a persistent sludge layer. For this reason, modern MGAs typically are specified to have the α content below *ca.* 3%.

These results demonstrate that the speed of modern calciners, and the variation of particle size and morphology, yields a non-equilibrium phase distribution, with clear structural differences both between and within individual alumina grains. This complex mixture of phases presents

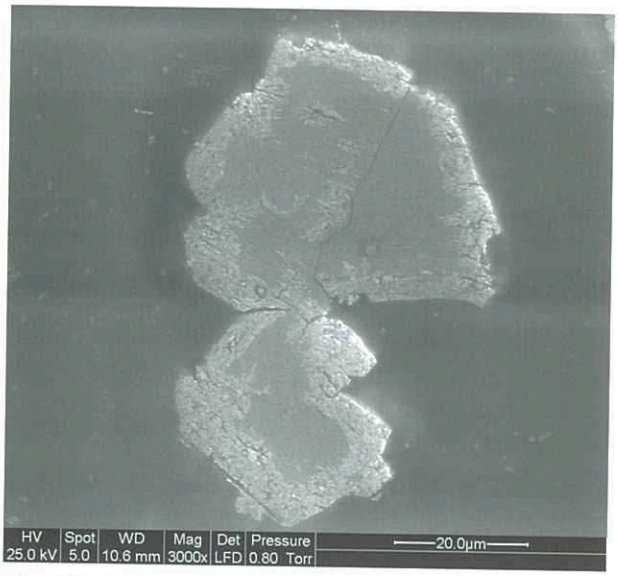


Fig. 6. Environmental SEM image of the cross-section of a relatively small industrial alumina grain showing significant phase differentiation across the section; phase distribution is influenced by the calcination conditions and calciner technology.

significant challenges in understanding their structure, particularly in relation to the performance as a raw material for the smelting process. A holistic approach, where order on different length scales is probed, is necessary for a more complete understanding of these materials.

Sidewall Refractories

Aluminium smelters drive production increases through increasing the amperage of individual reduction cells as well as increasing the number of reduction cells. The largest cells now operate at 500 kA while the largest smelters operate a 1000 or more reduction cells. The life of a cell, typically 5-7 years, is a critical parameter in economic viability, with costs approaching $0.3 M to rebuild the largest of the cells. Failure occurs usually through erosion of the graphitized or semi-graphitic carbon cathode, or through breaching of the sidewall refractory.

The sidewall in a high amperage cell is typically constructed from cemented blocks of silicon nitride-bonded silicon carbide (SNBSC). This material shows the optimal combination of resistance to molten cryolite, mechanical strength at operating temperature (*ca.* 1000 °C), and sufficient thermal conductivity to shed the required heat load through the sidewall. The latter point is critical as the refractory is protected, not by its corrosion resistance, but by maintaining a frozen layer of electrolyte at the hot face of the refractory. Corrosion resistance of this material, thus, is of considerable interest, as would be the development of a material inert to molten cryolite. The development of such a material would aid in the move towards an insulated cell, and, thus, the ability to reduce the current energy loss through the sidewall as waste heat. To put this in context, current energy consumption across the industry is stalled at a best practice of *ca.* 13 kWh/kg Al, almost exactly twice the theoretical requirement. Given the estimate that between 1 and 2% of the world's electrical power is being used to make aluminium, the potential energy savings are enormous.

SNBSC materials are formed by the high temperature nitridation of a green form containing SiC grains and a Si powder binder (Eq. 1).

$$3Si_{(s)} + 2N_{2(g)} = Si_3N_{4(s)} \qquad \Delta H = -824.7\ kJ/mol \ldots. \text{Eq. 1}$$

This leads to a composite material in which the SiC grains are supported in a Si_3N_4 binder phase. However, not all SNBSC materials are created equal and this leads to unpredictable, and occasionally short, lifetimes in the cell.[20] Microstructural analysis of SNBSC materials, before and after use, has been undertaken by X-ray diffraction, solid state Si MAS NMR,[21] and SEM, to examine the degradation of these materials in a variety of cell environments. These studies identify, for example, significant variations in the α/β Si_3N_4 ratio and porosity in the binder phase, both between manufacturers and as a function of location within an individual refractory brick.[22] Typically, higher porosity levels and β Si_3N_4 content are found in the interior part of the brick where during manufacture, the nitridation reaction occurs both later and at higher temperatures.[23]

SNBSC samples were tested in a laboratory-scale aluminium reduction cell. A testing rig with some novel features, such as a rotating anode (Fig. 7), was developed to examine corrosion resistance of samples under electrolysis conditions in molten cryolite at up to 1000 °C. Corrosion test results, supported by thermodynamic calculations, identify the Si_3N_4 binder as the reactive phase in these materials, especially in the gas phase above the bath level.

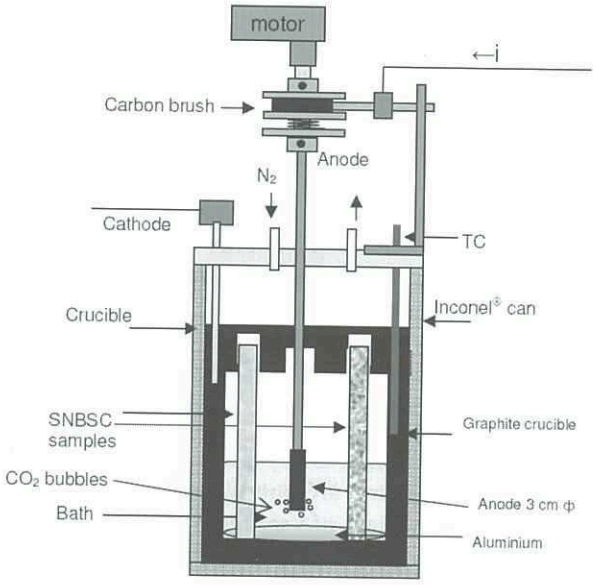


Fig. 7. Laboratory-scale corrosion testing rig.

The phase distribution within the binder is also relevant, with high β Si_3N_4 content showing a statistically significant contribution to the corrosion rate in lab-scale corrosion trials (Fig. 8). The crystal morphology of β Si_3N_4 is suggested as the reason for the high reactivity of these materials. This morphology, characterised by elongated rod-like crystals with hexagonal cross section, presents a higher surface area compared to α Si_3N_4 crystals containing mainly flat matte crystals.

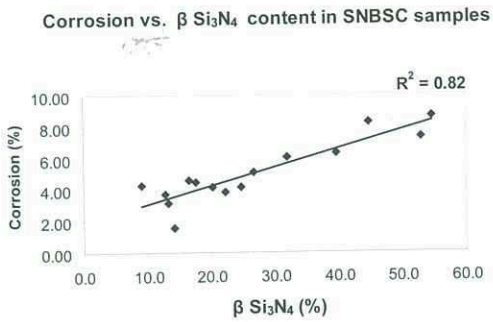


Fig. 8. Corrosion rate (% weight gain owing to the corrosion products) as a function of β Si_3N_4 content of SNBSC samples shows a high correlation.

The proposed corrosion mechanism for SNBSC materials in the aluminium reduction cell atmosphere is based, therefore, on a combination of oxidation of the binder followed by attack of corrosive gases, particularly HF, to produce volatile SiF_4. Thus, the binder phase is initially passivated below the electrolyte level on the sidewall, where exposure to corrosive gases is limited, but occurs more rapidly in the area of the sidewall above the electrolyte/air interface. The intrusion of electrolyte into the refractory and capillary and vapour transport up the sidewall is a key factor in accelerating this reaction.

Although these studies point to improved performance through better temperature control during nitridation, the major gains in sidewall technology will arise from the development of entirely new cryolite resistant materials which do not require a frozen ledge. We are currently looking into such materials in a joint project with several Australian Universities and the Light Metals Flagship programme of CSIRO.

Conclusions

Despite the maturity of the technologies used in alumina refining and aluminium smelting, a range of materials science, process control and performance constraints still limit improvements in energy consumption and the environmental footprint of this industry. The Auckland Light Metals Research Centre has been prominent in both the underpinning research and technical support of the industry to address these challenges.

Metallurgical aluminas, as opposed to those produced for the chemical industry, are poorly understood materials, particularly in the light of very rapid calcination process typically used to produce modern MGAs. The structural analysis of these materials and understanding their performance in the smelter continues to be a challenge, although significant advances have been made over the past decade. Sidewall refractories are another area where reduction cell design and the energy efficiency of the smelting process is constrained by materials science limitations. Although the corrosion of SNBSC refractories is now better understood, we are no closer to a viable sidewall inert to molten cryolite.

Acknowledgements

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Antioxidant Plastics based upon Conducting Polymers

Paul A. Kilmartin*

Polymer Electronics Research Centre, Chemistry Department, University of Auckland, Private Bag 92019, Auckland (e-mail: *p.kilmartin@auckland.ac.nz*)

Introduction: Active Packaging

The packaging industry increasingly is turning to polymer chemists and engineers to develop novel plastic materials with added active functions. In addition to containing a food product or pharmaceutical, the packaging then assists in prolonging the product's shelf-life or improving convenience, *e.g.* through moisture or oxygen control. Further active agents can include ethylene scavengers and antimicrobial compounds such as ascorbic acid. One of the most widespread types of active packaging involves the addition of oxygen scavengers. In the food industry, these scavengers are designed to lessen oxidative damage, such as rancidity in oils and fats, discolouration of meats, and loss of nutritive elements. To be effective, the scavengers need to be able to absorb large quantities of oxygen, be economically priced and preferably recyclable, and, importantly, contain no toxic products that will come in contact with the consumer.

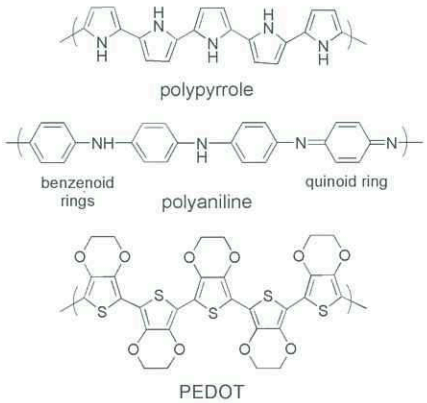
One of the most effective means of removing oxygen from within a package is the inclusion of small sachets containing powdered iron. In other cases an active oxygen scavenger is embedded in the packaging itself. The active material then lowers the internal oxygen concentration by removing oxygen that would otherwise migrate through the plastic. Examples include nylon MXD6 as a high gas barrier resin that is easy to recycle, and which can be prepared as a single layer blend with a beverage plastic such as PET (polyethylene terephthalate) or as a multilayer construction where the scavenger is included within an inner layer. In some cases a cobalt catalyst is added to improve the scavenging properties of the nylon. Another alternative is to incorporate small molecule antioxidants, such as ascorbic acid or sulfites, or to employ an unsaturated organic polymer that can be oxidised and thereby remove oxygen coming through the packaging. In trials on red wines stored in PET bottles with the inclusion of a polyester copolymer oxygen scavenger, the oxygen permeability was found to be decreased by more than 10-fold.[1] Tests over 170 days showed that SO_2, anthocyanin and flavanol retention was greatest in the PET containers with the oxygen scavenger included. The containers performed even better than storage in glass and this is ascribed to the ability of the scavenger within the PET to remove oxygen already dissolved in the wine.

A further related concept in active packaging is the inclusion of antioxidants with radical scavenging properties. These range from the classic antioxidant vitamins, such as α-tocopherol and β-carotene, through to the more stable synthetic antioxidants, such as butylated hydroxylanisole (BHA) and butylated hyrdoxytoluene (BHT). These antioxidants scavenge free radicals to lessen rancidification in oils and fats, and so they can be included in the plastic packaging, both to retard the oxidation and the degradation of the plastic itself, and to prolong the shelf-life of products coming in contact with the packaging. At the same time the small molecule antioxidants might leach out of the packaging material, which is not always desirable.

Conducting Polymers

Plastics that conduct electricity is a concept that has become very familiar to NZ chemists, particularly following the 2000 Nobel Prize awarded to Alan MacDiarmid, Hideki Shirakawa (Japan) and Alan Hegger (USA) for work on conducting polymers. Polymers with good environmental stability that are easy to prepare, *e.g.* polypyrrole (PPy), polyaniline (PANI) and poly(3,4-ethylenedioxythiophene) (PEDOT) (Chart 1), have attracted considerable research attention and are being considered in a diverse range of applications such as plastic solar cells, actuators and in biosensing.[2] In some cases, the high conductivity of the polymers in the doped state is important, while in others it is the ability of the polymers to be reversibly oxidised and reduced, *viz.* to be redox-active, that is the important consideration. Oxidized PPy has been found to be a suitable material for *in vitro* nerve cell culture and for the controlled release of drugs.[3,4] An important consideration for *in vivo* applications is the toxicity for PPy, which to date has been found to be low, pointing to good biocompatibility.[5] In further studies, PPy particles did not induce a cytotoxic effect in experiments on mouse cells[6] and showed no evidence of systemic toxicity around the rat sciatic nerve.[7] Biocompatability studies have been extended more recently to consider cell proliferation on PPy substrates.[8]

Chart 1. Structures of three common conducting polymers



Antioxidants and Radical Scavenging Test Procedures

Dietary antioxidants such as vitamin C, vitamin E and polyphenols appear to offer protection against cardiovascular diseases and cancers.[9] They can also act as preservatives in foods, and in the case of lipid-soluble antioxidants can help limit the onset of rancidity, especially for foods

rich in polyunsaturated fats. An excessive production of free radicals is thought to be responsible for high levels of oxidative damage, whereby species that contain unpaired electrons react with biomolecules to cause cellular injury and death.[10] The mechanism of action of antioxidants can include chelation of pro-oxidative metals, oxygen scavenging and free radical termination.[11] Antioxidants can then be defined as compounds present in foods or in the body in small amounts that prevent or inhibit reactions promoted by oxygen and radicals such as peroxides.

As the ultimate effects of a good dietary supply of antioxidants in the body or the inclusion of preservative antioxidants, such as SO_2 or ascorbic acid, in beverages is only realized over a time-frame of years, more rapid antioxidant capacity tests have been developed for food and biomedical studies. These rapid bench-top assays, many of which provide a measure of the free radical scavenging of the antioxidant compounds present, have inevitable limitations but can be used to provide an indication of the potential, or capacity, for antioxidant activity, *e.g.* of a glass of red wine. The main antioxidant capacity test procedures have been classified as either single electron transfer (ET) assays or hydrogen atom transfer (HAT) assays.[12] An example of an ET-based method, in which antioxidants reduce a supplied oxidant radical, is the 2,2'-azinobis(3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) assay, based upon their reaction with the ferrylmyoglobin radical, formed through activation of metmyoglobin by hydrogen peroxide, or alternatively by the reaction of ABTS with potassium persulfate, to produce the coloured radical cation $ABTS^{\bullet+}$.[13] Antioxidants can quench the $ABTS^{\bullet+}$ radical and thereby decolourise the reaction mixture, which is monitored by a spectrophotometer at 753 nm. The ABTS assay is applicable to both lipophilic and hydrophilic phases.[13] A further ET method is the α,α-diphenyl-β-picrylhydrazyl (DPPH) assay, in which a more effective radical scavenger removes the purple coloured DPPH radical more rapidly and/or more completely.[14,15] Both of these assays have been widely applied to measure the total antioxidant capacity of foods and beverages.[16] An example of an HAT-based assay is the oxygen radical absorbance capacity (ORAC), in which the antioxidants and a substrate compete for peroxyl radicals generated by the decomposition of azo compounds. A further approach to testing the effectiveness of antioxidants is to set up accelerated aging trials in which a beverage or food oil is heated for several weeks, and the browning of the beverage, or degradation of the oil with build-up of peroxides, is monitored.

Conducting Polymers as Free Radical Scavengers

The role of polyanilines, alongside aromatic amines, in stabilising rubber mixes has been demonstrated, whereby polyaniline or poly(methoxyaniline) slowed down the rate of oxidation of the rubber itself.[17] Our interest in conducting polymers as antioxidants was stimulated by a recognition of the similar oxidation potentials of several polyphenol antioxidants, such as catechin and many of the common conducting polymers, indicating a similar strength as reducing agents.[18] This led us to test a number of commercially available *soluble* conducting polymers in the DPPH assay over a 30 minute test period, and the conducting polymers were found to be very effective free radical scavengers.[18,19] By using electrochemical tests to evaluate the potential at which the DPPH radical is reduced in a methanolic test solution, itself a weak oxidising agent, the high effectiveness of the conducting polymers relative to the original aniline and pyrrole monomers could be understood. Likewise, the high scavenging activity in the DPPH assay of certain groups of polyphenols, namely those with more readily oxidizeable catechol and galloyl groups, was also explained relative to the low response observed for polyphenols with more isolated phenol groups that are more difficult to oxidise. This observation is important in understanding differences obtained with the DPPH assay for food and beverage extracts compared to measures of polyphenol content such as the Folin-Ciocalteau assay.[20]

In further investigations various spectroscopic measurements were applied to solid conducting polymer samples, mainly polyaniline, before and after exposure to a DPPH test solution, including EPR, XPS, and solid state NMR, using both ^{13}C and ^{15}N NMR studies. For this work and in subsequent studies, the conducting polymer powders were prepared using ammonium persulfate as the oxidising agent to effect the required chemical polymerisations. The various spectroscopic studies confirmed that polyaniline was oxidised in the course of the DPPH test and that, indeed, it had acted as a reducing agent, while no evidence was seen for additional chemical binding or trapping of the DPPH radicals within the polyaniline structure.[21,22]

Solid conducting polymer samples created some difficulties with standard DPPH test protocols, where 1.5 mL of a 72 μM solution of coloured DPPH radicals (with an initial absorbance maximum at 516 nm of around 0.65 units) was typically employed. The first issue centered around a nearly complete removal of DPPH radicals within a couple of minutes when just 1 mg of conducting polymer was employed. This means that conducting polymer samples could not be differentiated using the existing methodology. The final form of the DPPH assay now involves 20 mL of a 255 μM solution of DPPH radicals and 1.0 mg conducting polymer samples with controlled shaking during the reaction period.[23] Even though the initial absorbance reading is around 2.6 units, final readings in the 0.5 to 1.0 range are typically obtained, allowing comparisons between conducting polymer samples to be made. Under these conditions, the scavenging of DPPH radicals continues well beyond the 30 minute test period typically employed for small molecule antioxidants in solution. Differences between soluble antioxidants and the solid conducting polymers contribute to this effect, along with the wide range of oxidation potentials of the conducting polymer structural units (seen also in the broad oxidation curves typical of cyclic voltammograms). The test procedure has thus been extended to 24 hours of reaction time before the final readings are taken.

Owing to variations in the performance of the antioxidant capacity assays, there is a current trend to apply a range of test procedures to confirm experimental findings. The

ABTS assay has thus been adapted for use with conducting polymer powders in a 3 hour test procedure.[24] Likewise, the ORAC assay has been adapted for use with conducting polymer-containing films.[25] With these test procedures in place, it has been possible to assess the radical scavenging efficiency of different conducting polymers. In their as-prepared, partially oxidised forms, polypyrrole and polyaniline showed more effective radical scavenging than PEDOT, both on a mass basis, and in the number of monomer units required to scavenge each free radical (Table 1). Similar results were obtained using both DPPH and ABTS assays, although the polymers were able to scavenge more DPPH than ABTS radicals. This trend was observed despite that fact that the ABTS radical is a stronger oxidizing agent than the DPPH radical, suggesting that further properties are at work in determining the extent of radical scavenging than oxidation strength alone.[24]

Table 1. Comparison of $DPPH^{\cdot}$ and $ABTS^{\cdot+}$ scavenging activity of the as-prepared conducting polymers, expressed as the ratio of the number of monomer units required per free radical scavenged.[a]

	PPy	*PANI*	*PEDOT*
$ABTS^{\cdot+}$	6:1	4:1	7:1
$DPPH^{\cdot}$	3:1	2:1	8:1

[a]Data taken from ref. 24

It was further established that pre-reduced forms of the conducting polymer powders, obtained by reduction with hydrazine, were even more effective free-radical scavengers than the as-prepared partially oxidised forms (Fig. 1), consistent with the expected redox interaction involved.[24,26] The available surface area is also expected to be important in determining the extent of radical scavenging: PANI nanofibres of decreasing average diameter have been shown to exhibit a greater radical scavenging ability in the DPPH assay.[27] The enhanced antioxidant activity was attributed to the increased surface area of the PANI nanofibres, a result obtained in a further study on PANI nanofibres.[28] We have also found that PANI prepared conventionally in the presence of a strong acid such as sulfuric acid, consisting of granular PANI particles, was less effective than PANI prepared without added acid, in which high surface area nanotubes are formed (Fig. 2). This was seen in the DPPH assay (Fig. 3), and in the ABTS assay.[24] That said, the higher scavenging of DPPH radicals of the nanotube form may be related as much to the initial oxidation state of the PANI products, as to the surface area of the different polymer forms.

Conducting Polymer Blends

Conducting polymers on their own are not immediately suitable as a plastic packaging materials, as they lack the necessary mechanical properties. Forming blends between conducting polymers and food-grade plastics is the next step to consider, with the aim of retaining the mechanical properties of the packaging material and the radical scavenging activity of the conducting polymer. Blends between conducting polymers and both ethyl cellulose and polyethylene have been developed at the University of Auckland and form the basis of a provisional patent.[25,29]

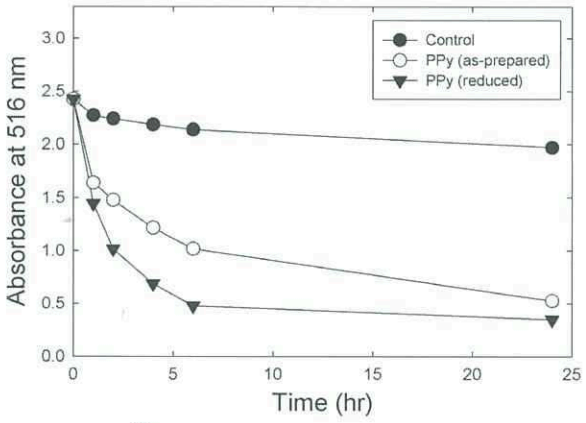


Fig. 1. Decline in the 516 nm absorbance of a 225 μM methanolic solution of DPPH radicals with 1.0 mg of PPy powders added.

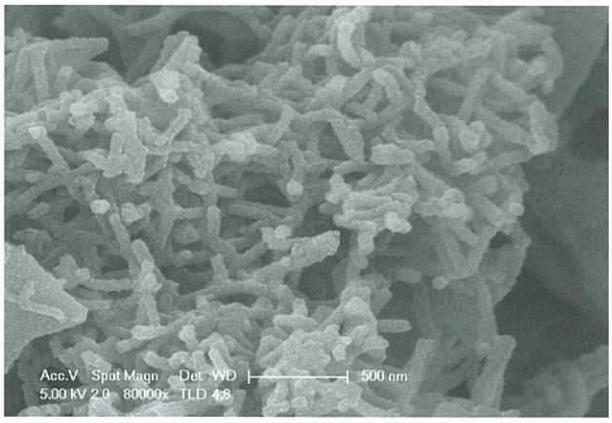


Fig. 2. SEM image of polyaniline nanotubes from oxidation of aniline by ammonium persulfate in the absence of strong acids (500 nm scale bar).

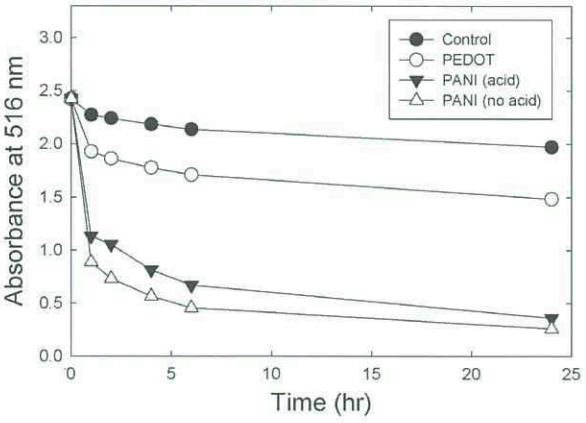


Fig. 3. Decline in the 516 nm absorbance of a 225 μM methanolic solution of DPPH radicals with 1.0 mg of PANI and PEDOT powders added.

Polyaniline has been blended with ethyl cellulose (EC) via dispersion in ethanol prior to casting and solvent removal to produce PANI/EC films. The ORAC assay was readily applied to the films, and it was found that the greater the size of the PANI/EC film present, the more effectively it competed with fluorescein for the peroxyl radicals, leading to a longer delay in fluorescence decay and correspondingly larger *ORAC area* (Fig. 4). Once again, films containing reduced PANI were more effec-

tive radical scavengers. In each case, the results indicated that active conducting polymer was available to the test solution and was not completely blocked by the presence of ethyl cellulose, even though the films themselves had very low conductivity values. To extend the test procedures to a real food sample, fish oils were subject to accelerated degradation at 60 °C in the presence of air, leading to considerable oil oxidation and the build up of peroxides. PANI/EC films were able to slow down the rate of oxidation to a measureable extent, although the benefit was only slightly better with a film containing 20% PANI compared to one prepared with 10% PANI (Fig. 5).

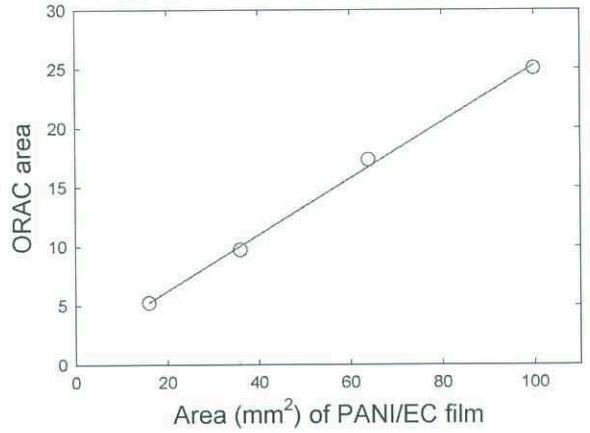


Fig. 4. Response of PANI/ethyl cellulose films in the ORAC antiradical assay.

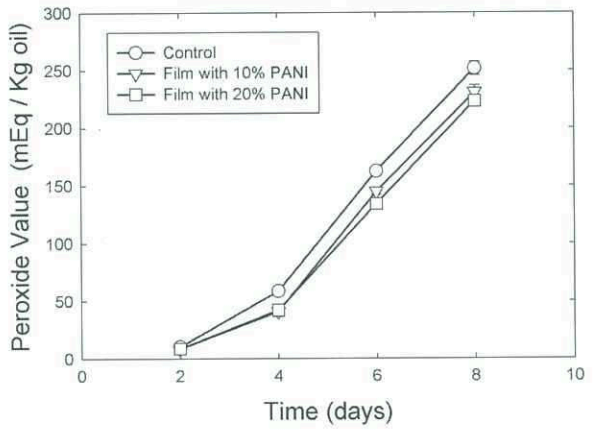


Fig.5. Accelerated stability test on a fish oil using PANI/ethyl cellulose films; 60 °C with exposure to the air ($n = 3$).

Ethyl cellulose is an interesting cellulose derivative that can be used as a thin-film coating material, but the thermoplastic polymer polyethylene (PE) is much more widely applied, with an annual production of around 80 million tons world-wide. Blending of PANI and PE has also been achieved through compression moulding at 180 °C. With the inclusion of 12% PANI (Fig. 6), very good mechanical properties of the PE were retained and effective radical scavenging again established. Like the famous Ford Model T motor car, these films are currently available in any colour, as long as it is black! Through the inclusion of a polymeric antioxidant in the blend, rather than small molecule antioxidants, the issue of the leaching of the antioxidant out into the packaged product is minimised, provided that high molecular weight conducting polymers are used and smaller oligomeric units are removed prior to blending.

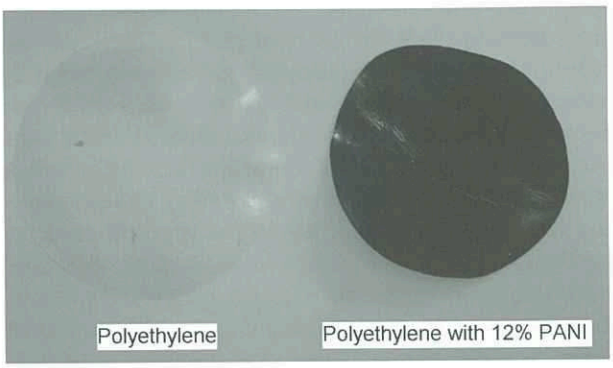


Fig. 6. Photograph of two polyethylene pressed disks (11 cm diam.); that at right contains 12% PANI by weight.

Final Remarks

Conducting polymers have been shown to be effective free radical scavengers, related to their ability to be oxidised in a similar potential range to small molecule antioxidants. Several conventional food science radical scavenging assays and accelerated storage procedures have been adapted to solid conducting polymers to evaluate the effectiveness of different samples and preparations. At the same time, the applied test assays can be considered as a useful means of assessing the available redox activity of conducting polymers when present in blends or as surface coatings. This provides important information on surface properties that can complement conductivity measurements, in particular.

The prospects for active packaging involving conducting polymers remain very promising where the effects of a solid antioxidant material can be used to extend product shelf-life. The radical scavenging property of conducting polymers also needs to be kept in mind when various biomedical applications are being developed, *e.g.* in nerve regeneration, wound healing and artificial muscles. This is because the scavenging of free radicals may assist in lowering levels of oxidative stress in the tissues and fluids in immediate contact with the conducting polymer.

Acknowledgements

Research into conducting polymers as antioxidants has involved several projects over the past seven years. I am grateful to my collaborators Drs Allan Easteal and Jadranka Travas-Sejdic, and Profs. Graham Bowmaker and Ralph Cooney. The research studies of Drs. Marija Gizdavic-Nikolaidis, Chyong Fang Hsu, Zoran Zujovic, Hui Peng and Lijuan Zhang, and Corrina Thompson, Richard Delgenes, Cedric Basle and Ashveen Nand have led to the results described herein.

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Article

The Mechanism of Mutation Initiated by One-Electron Oxidation

Jóhannes Reynisson

Department of Chemistry & Auckland Bioengineering Institute, University of Auckland, Private Bag 92019, Auckland (e-mail: *j.reynisson@auckland.ac.nz*)

Introduction

The aqueous redox chemistry of the nucleosides and nucleotides has been extensively investigated for the last 40 years using pulse radiolysis, laser photolysis, electron spin resonance, and other time resolved and steady state techniques.[1] More recently, theoretical methods have been employed in the study of redox damage of DNA.[1] This intensive interest in the components of DNA is understandable since it carries our genetic code and, if damaged, can lead to mutations possibly resulting in cancer.[2,3] Furthermore, oxidative damage of DNA is implicated in aging[4] and drug resistance of bacteria.[5] It is now understood that DNA damage initiated by ionising radiation elicits a complicated set of events engaging various signalling pathways in cells.[6]

Deprotonation Alters Hydrogen Bonding Capabilities

Interestingly, it has been found that when organic molecules are one-electron oxidized in the aqueous phase, a rapid deprotonation occurs from hydrogen bond donors, undoubtedly driven by the massive solvation energy of the proton (ΔG_{aq} = –263.9 kcal/mol).[7-9] Thus, the pK_a of cytosine (**C**) is lowered from 12.15 to lie between 2 and 4 when **C** is one-electron oxidised.[8,10,11] With respect to DNA, guanine (**G**) is its most easily oxidized component[12] and when double stranded DNA's π-stack loses an electron, the positive charge migrates to **G-C** rich areas in the double strand.[13-16] The pK_a of **G** is lowered significantly from 9.4 to 3.9 at the nitrogen-1 atom (N1) as depicted in Fig. 1.[10,17,18]

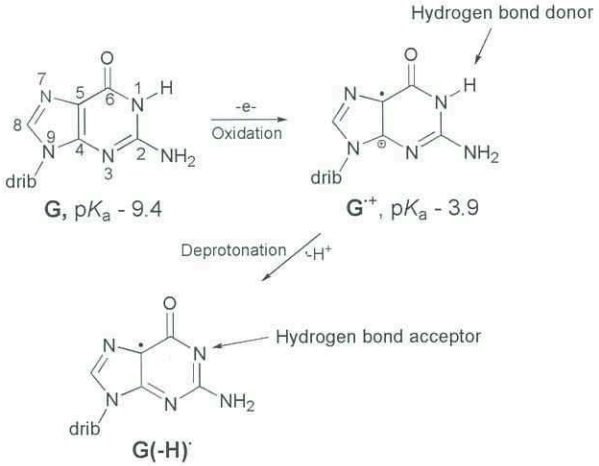

Fig. 1. Oxidation and deprotonation of guanine (**G**) and its radical cation (**G**$^{\bullet+}$): The pK_a of **G** is drastically lowered upon one-electron oxidation and the subsequent deprotonation of N1–H changes it from a hydrogen bond donor to a hydrogen bond acceptor; the numbers of the atoms constituting **G** are shown and drib is a 2'-deoxyribose moiety.

After departure of the proton from the N1-site, it becomes a hydrogen bond acceptor instead of a hydrogen bond donor. The question emerged as to whether this event leads to a change in the pairing ability of the **G** moiety with other bases.[19] In fact, it is a common view that ligand hydrophobicity gives affinity, whereas hydrogen bonding gives specificity for interactions in biochemical systems.[20] Simulating one-electron oxidation and the consequent deprotonation of the central N1-proton for **G–C** using density functional theory (DFT),[21] a new slipped configuration of the base pair was formed as depicted in Fig. 2.[19] This slipped configuration, **G**(-H)$^{\bullet}$-**C**, was later independently derived by Bera *et al.* using a systematic search for all possible hydrogen bonding configurations between **G**(-H)$^{\bullet}$ and **C**.[22] The predicted base pairing energy (BPE) is –18.2 kcal/mol for **G**(-H)$^{\bullet}$–**C**.[19,23] It lies between the BPE's of the adenine–thymine base pair (**A–T**) at –13.0 kcal/mol and of **G–C** of –21.0 kcal/mol.[24,25]

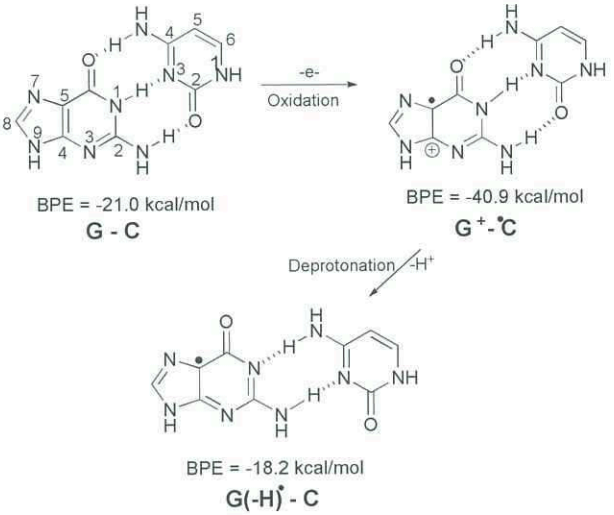

Fig. 2. Deprotonation-induced structural change of the **G–C** base pair initiated by one-electron oxidation leading to the shifted base pair **G**(-H)$^{\bullet}$-**C**; BPE = Base Pairing Energy.

The Situation in Double Stranded DNA

Under what circumstances can **G**$^{\bullet+}$–**C** in the DNA stack lose the central N1 proton making up one of the Watson–Crick hydrogen bonds? It does not have access to the aqueous phase since it is the central hydrogen bond and it is flanked by base pairs on either side in the double stranded DNA helix. It is imperative that N1–H comes into contact with the water phase (water acting as a proton acceptor), *i.e.* within **G–C** the **G**(N1–H)–**C**(N3) Watson–Crick hydrogen bond has to be broken for the N1 proton to be lost (see Fig. 2). The hydrogen bonds between the base pairs may be broken in any of three situations. First is the *swing-out* of the bases by concerted thermal motions of the DNA strand.[26,27] This mechanism

is unlikely since it takes place on the milli-to-micro second time scale and it is in competition with further charge migration in the DNA helix and/or with water addition to C8 of $\mathbf{G}^{\bullet+}$. The rates of these processes are estimated as 5×10^7/s and 6×10^4/s, respectively, *i.e.* in the micro–nanosecond timescale.[16,28] Furthermore, the BPE of $\mathbf{G}^{\bullet+}$–**C** is increased to –40.9 kcal/mol compared to –21.0 kcal/mol of its parent pair inhibiting the frequency of the breathing motions of the base pair.[24,29,30] Second, when duplication of DNA occurs, the DNA strand is untwisted and the hydrogen bonds between the bases are broken to allow the duplication of the strand. Third, the H-bonds may be broken during DNA transcription to messenger RNA as this proceeds in a manner similar to the duplication of DNA. Also, it has been suggested that deprotonation occurs from the exocyclic amine group of **C** in $\mathbf{G}^{\bullet+}$–**C**, based on pulse-radiolysis and kinetic isotope experiments.[31-33] The proposed deprotonation mechanism is shown in Fig. 3. This reaction cascade can lead to the **G**(-H)$^{\bullet}$–**C** slipped configuration.[34]

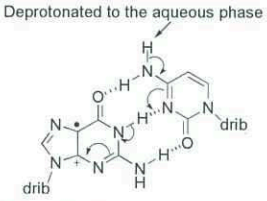

Fig. 3. Possible mechanism involving the *exo*cyclic amine moiety of **C** as proton donor of the one-electron oxidized base pair; the initial charge sits on **G** in the complementary strand; spin-charge separation between **G** and **C** plays a crucial role in the reaction cascade and the depicted deprotonation can lead to the formation of **G**(–H)$^{\bullet}$–**C** –see ref. 34.

Base Pairing of the Deprotonated Guanine Radical

A related question emerged as to whether it is possible to pair **T**, **A** and **G** itself to **G**(–H)$^{\bullet}$. This was investigated using the DFT method and the results are presented in Fig. 4.[19]

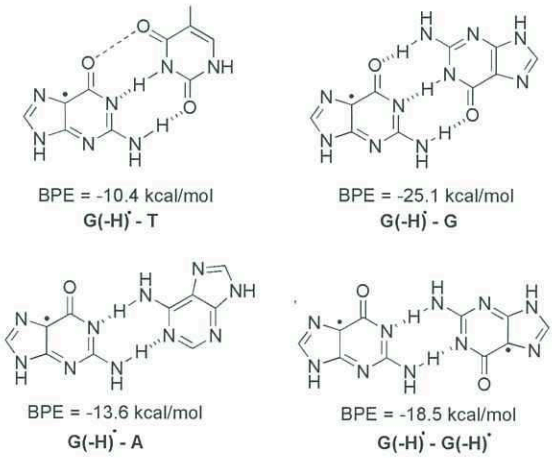

Fig. 4. The unnatural base pairs between **G**(–H)$^{\bullet}$ and the other bases – see ref. 19 The substantial base pairing energy (BPE) for the non-classical complexes depicted leads to the conclusion that **G**(–H)$^{\bullet}$ does not have any specificity for **C**.

Armed with the knowledge of the **G**(–H)$^{\bullet}$–**C** base pair with only two hydrogen bonds, **G**(–H)$^{\bullet}$ was paired to **T** and structurally optimized. The BPE was calculated to be –10.4 kcal/mol for **G**(–H)$^{\bullet}$–**T**, which is comparable to the **A**–**T** base pairing energy (–13.0 kcal/mol).[24,25,29,35] The relatively low energy can be explained in terms of the non-planarity of the bases with respect to each other. From the calculations, they appear to be *ca.* 25° out of plane, measured at their carbonyl groups O^6 (**G**) and O^4 (**T**). The distance between these oxygen atoms is 3.5 Å, a proximity which leads to Coulombic repulsion and hence the non-planar conformation. The calculated hydrogen bonding energy of **G**(–H)$^{\bullet}$–**A** base pair is –13.6 kcal/mol, as shown in Fig. 4. This binding is somewhat stronger than for the natural **A**–**T** pairing (–13.0 kcal/mol).[24,25,29,35]

The hydrogen bond energy of **G**(–H)$^{\bullet}$–**G** (see Fig. 4) is similar to that of **G**–**C**.[36] This is not surprising because three hydrogen bonds are present in both structures. A second type of a **G**–**G** base pair is conceivable between two **G**(–H)$^{\bullet}$ moieties [**G**(–H)$^{\bullet}$–**G**(–H)$^{\bullet}$], as shown in Fig. 4. For this, the hydrogen bond energy is –18.5 kcal/mol, somewhat lower than for **G**(H)$^{\bullet}$–**G** since it has one less hydrogen bond. Pt(II) electrophile coordinates at N7 of **G**. This acidifies the N1 proton, akin to what happens during the oxidation of G. With these Pt-**G** species, structures similar to **G**(–H)$^{\bullet}$–**G** and **G**(–H)$^{\bullet}$–**G**(–H)$^{\bullet}$ were observed by ^{1}H-NMR and X-ray crystallography,[37] thus providing experimental evidence for their existence.

Oxidation During DNA Duplication

Using *in situ* photolysis electron paramagnetic resonance (EPR), Hildenbrand and Schulte-Frohlinde detected a long-lived radical (lifetime ~5 s) that was produced only from double stranded DNA when ionised with ≤ 220 nm light in an aqueous solution at pH ~7.[38] This radical was assigned to **G**(–H)$^{\bullet}$. The rate of DNA duplication was measured to lie between 5 and 500 nucleotides per second depending on the cell type, the species and other factors.[39,40] Considering the long lifetime of **G**(–H)$^{\bullet}$ in double stranded DNA and the rapid DNA duplication rate, the scenario emerges that in case of one-electron oxidation during mitosis-/-meiosis **G**(–H)$^{\bullet}$ is formed when the two strands unwind. As shown in Fig. 4, base pairs can form with all of the nucleotides with binding energies similar to the classical **A**–**T** and **G**–**C** Watson-Crick base pairs. This means that **G**(–H)$^{\bullet}$ does not have specific affinity for **C**, *i.e*, it is completely promiscuous when it comes to base pairing. Therefore **G**(–H)$^{\bullet}$ can pair with all of the nucleotides and lead to mispairing. A depiction of this scenario is presented graphically in Fig. 5.

The mechanism presented here is new and provides an alternative to the scenario that mispairing of the DNA bases is mostly caused by oxidative end products such as 7,8-dihydro-8-oxoguanine (**8-OG**). These products are closed shell, i.e, they are not radical species and, therefore, have much longer lifetimes than **G**(–H)$^{\bullet}$. Redox product **8OG** is one of many derived from DNA one-electron oxidation and subsequent water addition to **G**.[17,18,41] It can form syn-anti base pairs[42] with all of the nucleotides and these have base pairing energies of ~ –10 kcal/mol.[43] The **8OG**–**A** base pair is depicted in Fig. 6 as an example of *syn-anti* base pairs.

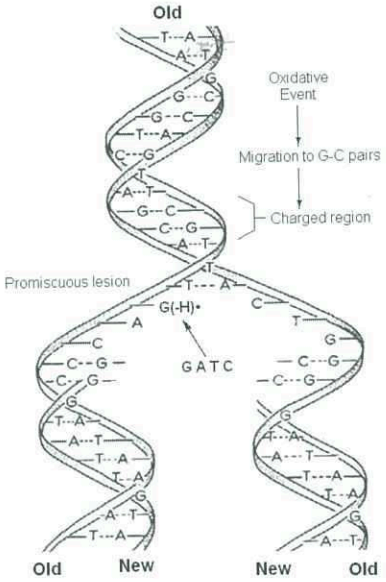

Fig. 5. As the two strands of the double helix unwind, each pairs up with the appropriate bases to form a new double helix. The two new helices are identical to each other and to the original. This process is compromised by one-electron oxidation of the π-DNA stack, deprotonation from $\mathbf{G}^{\bullet+}$ and the subsequent formation of $\mathbf{G}(-\mathrm{H})^{\bullet}$ that is promiscuous in regard to base pairing.

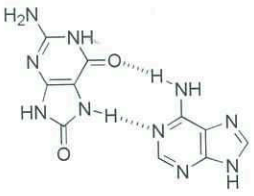

Fig. 6. The *syn-anti* base pair of **8OG-A**; BPE = Base Pairing Energy.

Conclusions

In this review, an alternative mechanism for promiscuous base pairing during DNA duplication initiated by one-electron oxidation is proposed based on theoretical calculations. Some experimental results that support the existence of the non-classical base pairs discussed exists, *i.e.* for the slipped $\mathbf{G}(-\mathrm{H})^{\bullet}$–**C** and the $\mathbf{G}(-\mathrm{H})^{\bullet}$–**G** base pairs. Further experimental and theoretical work is needed to corroborate the mechanism proposed. In particular, experiments conducted with time resolved resonance Raman spectroscopy on model DNA duplication systems are pertinent.

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On the Origin of the Dimeric Aplysinopsin Alkaloids

Emily M. Boyd and Jonathan Sperry*

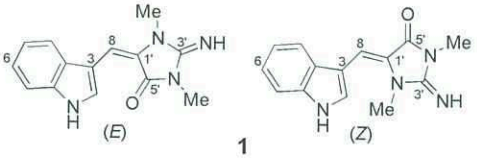
Department of Chemistry, University of Auckland, 23 Symonds Street, Auckland
(e-mail: *j.sperry@auckland.ac.nz*)

Introduction

The aplysinopsins comprise a group of compounds isolated from marine sources and are unusual in that they contain a series of dimers of unexplained biogenetic origin. These dimers have long been thought to arise from the Diels-Alder cycloaddition between two monomers with one acting as the diene and the other as the dienophile. However, recent findings have evoked a possible second biosynthetic pathway whereby the dimers are formed by the rearrangement of a corresponding dimeric cyclobutane aplysinopsin. A chronological history of this fascinating class of alkaloids is discussed herein.

Monomeric Aplysinopsins

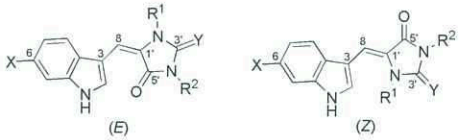
In 1977, Wells and co-workers isolated two novel tryptophan-based secondary metabolites from the sponges *Thorecta* sp. collected from the Australian Great Barrier Reef.[1] These natural products were subsequently named aplysinopsin (**1**) and 3'-deimino-3'-oxoaplysinopsin (**2**) that occur as (*E*)- and (*Z*)-isomers (below and Table 1).[1] It was shown that **1** existed as a mixture of double bond isomers (~ 9:1) of which the major isomer is the (*E*)-isomer.[2] The isolation report also confirmed the structure of **1** by synthesis. Condensation of indole-3-carbaldehyde with a creatinine derivative gave rise to **1** identical in every respect to the natural material.[1]



1

The years following Wells' initial report saw the isolation of several more aplysinopsin-type secondary metabolites (Table 1) and in the latter part of 1977, **1** was isolated from the sponge *Verongia spengelii*.[2] In 1980, an extract of the sponge *Dercitus* sp. from Belize was also shown to contain **1**, along with minor amounts of **3** and **4** (Table 1).[3] In late 1980, analysis of the extracts of the Caribbean sponge *Smenospongia aurea* afforded the novel 6-bromo-

Table 1. The family of monomeric aplysinopsins



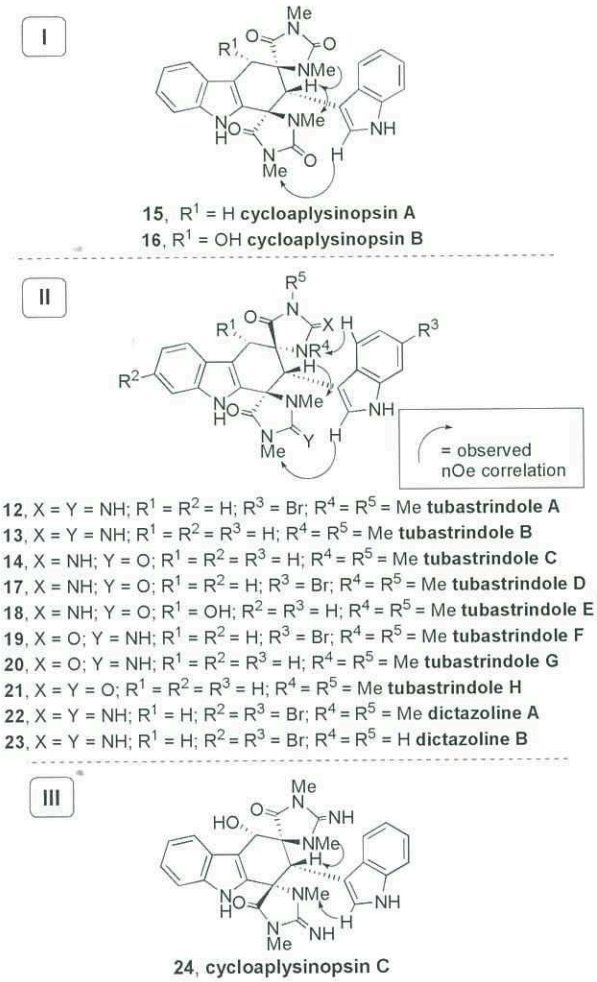
No.	Natural Product	R^1	R^2	X	Y	*E*/*Z* ratio	Ref. *E*/*Z* ratio
1	aplysinopsin	Me	Me	H	NH	> 95:5	10
2	3'-deimino-3'-oxo-aplysinopsin	Me	Me	H	O	> 95:5	10
3	2'-de-*N*-methyl-aplysinopsin	H	Me	H	NH	< 5:95	10
4	6-bromo-2'-de-*N*-methylaplysinopsin	H	Me	Br	NH	< 5:95	10
5	6-bromo-3'-deimino-2',4'-bis(demethyl)-3-oxoaplysinopsin	H	H	Br	O	1:1	9
6	*N*-methylaplysinopsin	Me	Me	H	NMe	High *E*	5
7	6-bromoaplysinopsin	Me	Me	Br	NH	100% *E*	5
8	6-bromo-3'-deimino-3'-oxoaplysinopsin	Me	Me	Br	O	5:2	9
9	3'-deimino-2',4'-bis(de-methyl)-3'-oxoaplysinopsin	H	H	H	O	<5:95	10
10	2'-demethyl-3'-*N*-methyl-aplysinopsin	H	Me	H	NMe	<5:95	10
11	6-bromo-2'-demethyl-3'-*N*-methylaplysinopsin	H	Me	Br	NMe	<5:95	10

3'-deimino derivative **5**[4] and, in 1981, the *N*-methyl **6** was isolated from *Aplysinopsis recticulata*.[5] Interestingly, various monomeric aplysinopsins have also been found in several scleractinian corals of the family Dendrophylliidae. In 1982, the extracts of *Tubastraea coccinea* revealed the presence of **3** and **4**, as well as the new natural product 6-bromoaplysinopsin (**7**).[6] Aplysinopsins **1** and **7** have been found in *Astroides calycularis*,[7] and **1** also from *Tubastraea aurea*.[8] In 1988, two novel 3'-oxoaplysinopsins were identified from two separate corals.[9] Thus, extracts of *Tubastraea* sp. contained **2** and the novel oxoaplysinopsin **8**, with the extracts of *Leptopsammia pruvoti* containing both the bis(demethyl)-3'-oxoaplysinopsin **5** and the novel bis(demethyl)-3'-oxoaplysinopsin **9**. A year later, two further analogues [2'-demethyl-3'-*N*-methylaplysinopsin (**10**) and its 6-bromo derivative (**11**)] were isolated from *Dendrophyllia* sp. along with **3** and **4**.[10] In a series of important findings, it was subsequently shown that various aplysinopsins undergo a thermally-reversible photoisomerization.[9] An instructive review regarding the synthetic efforts towards this monomeric class of natural products is available.[11]

The Dimeric Aplysinopsins

In 2000, the aplysinopsin story acquired a new dimension when it was reported that an extract of the coral *Tubastraea faulkneri* contained a dimer of **4**. This dimer was identified from the extract using *spectral and melting point analyses*, but the only spectroscopic information reported was the molecular weight.[12] It took a further three years before a fully characterized aplysinopsin dimer appeared.

Thus, the first fully characterized dimeric aplysinopsins were reported in 2003. Extracts of *Tubastraea* sp. contained the cyclohexenyl tubastrindoles A-C (**12-14**; Fig.1), along with aplysinopsin **1**[13] Around the same time, extracts of two corals afforded cycloaplysinopsin A (**15**), smaller amounts of B (**16**) and the known monomers **2** and **8**.[14] Interestingly, detailed 2-D NMR studies conducted by separate groups confirmed that the tubastrindoles A-C (**12-14**) and **15** and **16** possess different relative stereochemistry (Fig. 1). Further investigation of the extracts of *Tubastraea aurea* in 2008 led to the discovery of five further tubastrindoles D-H (**17-21**)[15] that had the same relative stereochemistry as previously established **12-14**.[13] The first dibrominated aplysinopsin dimers appeared when analysis of the extracts of the sponge *Smenospongia cerebriformis* afforded dictazolines A and B (**22** and **23**)[16] along with the previously described tubastrindoles **12** and **13**. Subsequently, dictazolines A and B were shown to have the same relative stereochemistry as all the previously isolated tubastrindoles.[13,15] In 2009 the isolation of a novel aplysinopsin dimer took the total number of distinct diastereomer classes to three when it was shown that the extracts of the sponge *Tubastraea* sp. (collected in Yemen) yielded cycloaplysinopsin C (**24**). Detailed 2-D NMR studies confirmed that **24** possesses different relative stereochemistry from both the previously described cycloaplysinopsins **15** and **16** (Class I) and the tubastrindoles and dictazolines **12-14**, and **17-23** (Class II) (Fig. 1).[17]



15, R^1 = H **cycloaplysinopsin A**
16, R^1 = OH **cycloaplysinopsin B**

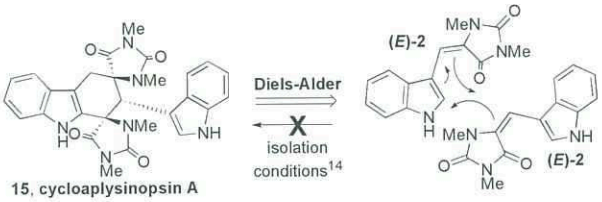
12, X = Y = NH; R^1 = R^2 = H; R^3 = Br; R^4 = R^5 = Me **tubastrindole A**
13, X = Y = NH; R^1 = R^2 = R^3 = H; R^4 = R^5 = Me **tubastrindole B**
14, X = NH; Y = O; R^1 = R^2 = R^3 = H; R^4 = R^5 = Me **tubastrindole C**
17, X = NH; Y = O; R^1 = R^2 = H; R^3 = Br; R^4 = R^5 = Me **tubastrindole D**
18, X = NH; Y = O; R^1 = OH; R^2 = R^3 = H; R^4 = R^5 = Me **tubastrindole E**
19, X = O; Y = NH; R^1 = R^2 = H; R^3 = Br; R^4 = R^5 = Me **tubastrindole F**
20, X = O; Y = NH; R^1 = R^2 = R^3 = H; R^4 = R^5 = Me **tubastrindole G**
21, X = Y = O; R^1 = R^2 = R^3 = H; R^4 = R^5 = Me **tubastrindole H**
22, X = Y = NH; R^1 = H; R^2 = R^3 = Br; R^4 = R^5 = Me **dictazoline A**
23, X = Y = NH; R^1 = H; R^2 = R^3 = Br; R^4 = R^5 = H **dictazoline B**

24, **cycloaplysinopsin C**

Fig. 1. Dimeric aplysinopsins and key nOe correlations.

Dimeric Aplysinopsins: Diels-Alder Cycloadducts?

When considering the biosynthetic origin of the cyclohexenyl aplysinopsin dimers, their structural similarity to the monomeric aplysinopsins is striking. Alas, in the vast majority of cases, the dimeric aplysinopsin is co-isolated from the same host organism along with its respective monomer, suggesting that the monomeric aplysinopsins are related to the dimers.[13,14] To investigate this possible relationship, Mancini and co-workers instigated an investigation involving **2** and its dimeric partner, cycloaplysinopsin A (**15**), two natural products isolated from the same coral. This group showed that subjecting synthetic **2** to the exact conditions used during the extraction process did not result in the formation of **15**. This suggests that cycloaplysinopsin A (**15**) is not an artefact of the isolation procedure and is indeed a natural product in its own right (Scheme 1).



15, **cycloaplysinopsin A**

Scheme 1. Diels-Alder cycloaddition with two molecules of (*E*)-**2**.

The observations regarding the biogenesis of the dimeric aplysinopsins present a fascinating possibility that they may, in fact, be cycloadducts of their respective aplysinopsin monomers. Diels-Alder cycloaddition is a credible pathway for this dimerization, whereby the monomeric aplysinopsin is acting both as the diene and the dienophile in the [4+2] process (Scheme 1).[13,14] After dimerization, further modifications occur in some cases, *i.e.* oxidation at C8 in the case of **16**, **18** and **24**.

What Promotes the Dimerization?

It is well established that cycloaplysinopsin **15** is not formed when subjecting the corresponding monomer, **2**, to the extraction conditions. This implies that an external entity associated with the host organism is aiding the dimerization in some way. Cycloaplysinopsins A-B (**15** and **16**) both possess a slight excess of one enantiomer (~30% ee), suggesting that, if a Diels-Alderase is responsible, it is enantio-defective.[14] However, Mancini and co-workers concluded that owing to the ongoing controversy over enzymes that catalyze concerted cycloaddition processes, it is more likely that the host organism (or associated symbiont) contains an adventitious Diels-Alder catalyst that aids the dimerization. Moreover, the chiral environment (steroids and other common metabolites) appears responsible for the slight asymmetric induction.[14] Presumably this postulate can be applied to other dimeric aplysinopsins, as Iwigawa and co-workers also concluded that because of the small optical rotation values seen in the tubastrindoles, it is highly likely that they exist as a mixture of both enantiomers.[15] However, further investigation into this proposal is hindered by the fact that many of the isolation reports do not disclose the enantiomeric excess of the dimeric aplysinopsins. Nonetheless, the Diels-Alder cycloaddition proposal offers potential insight into the different relative stereochemistry observed in the various dimeric compounds. It is possible that both (*E*)- and (*Z*)-aplysinopsins are viable substrates for the cycloaddition process and, as the vast majority of the monomeric aplysinopsins essentially exist as a single regioisomer (Table 1), it is conceivable that photoisomerization[9] is pivotal for the Diels-Alder reaction to proceed in some cases. Accordingly, the dimers can be grouped into three classes and used to rationalize the relative stereochemistry observed: Class I: (*E*)-diene and (*E*)-dienophile **15** and **16**; Class II: (*Z*)-diene and (*E*)-dienophile **12-14** and **17-23**; Class III (*E*)-diene and (*Z*)-dienophile **24** (Fig. 2).

As shown in Fig. 2, it is assumed that during the cycloaddition process, the diene and the dienophile are orientated as depicted. This is based on the orientation being the most favourable from MM calculations for (*E*)-**2** diene and (*E*)-**2** dienophile to give **15**.[14] However, it is also conceivable that **15** may be constructed from an *anti* approach of a (*Z*)-**2** diene and an (*E*)-**2** dienophile. Alas, it is equally feasible that the three distinct classes of diastereomers could arise through the dimerization of (*E*)- and (*Z*)-regioisomers in both *syn* and *anti* orientations.

Dictazoles and the Vinylcyclobutane Rearrangement

In early 2010, the proposed biosynthetic origins of the

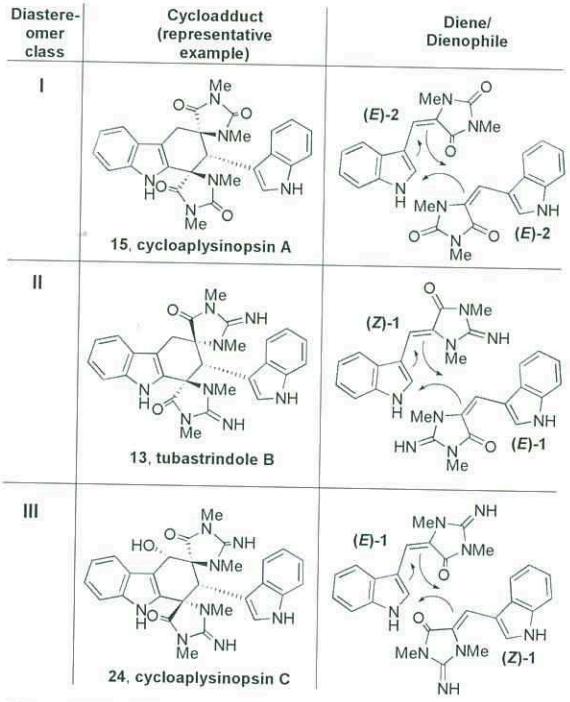


Fig. 2. Three diastereomer classes could arise from different cycloaddition pairs.

aplysinopsin dimers took another twist. Williams and co-workers reported the isolation of the three new dictazolines C-E (**25-27**), along with the structurally unique dictazoles A and B, **28** and **29**, respectively,[18] from the same extract of *S. cerebriformis* that had earlier afforded dictazolines A and B (**22** and **23**)[16] (Fig. 3). Interestingly, the authors did not report the isolation of any monomeric aplysinopsins.

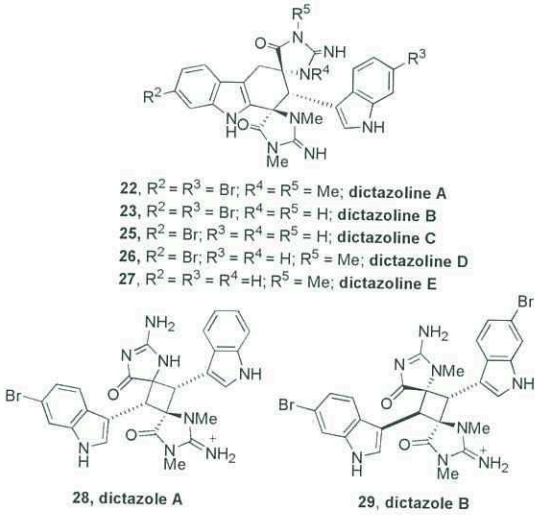
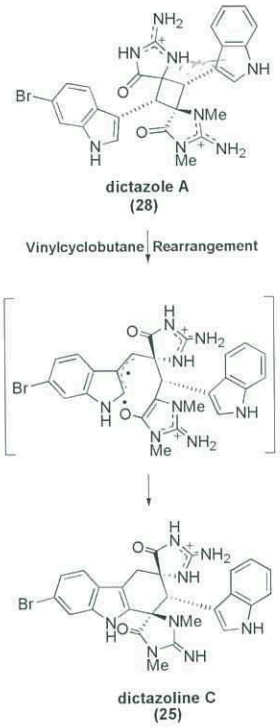


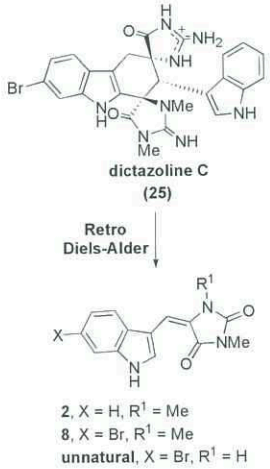
Fig. 3. Dictazolines A-E and dictazoles A and B.

Using Baran's pioneering biomimetic total synthesis of ageliferin from the cyclobutane sceptrin as a guide,[19] the authors suggested that the dictazoles are possible precursors to the corresponding dictazolines. Specifically, dictazole A (**28**) can be converted to dictazoline C (**25**) via the vinylcyclobutane rearrangement, as outlined in Scheme 2.[18] Circumstantial evidence supporting this proposed pathway is the relative abundance of these isolated compounds; the cyclobutane derivative **28** is isolated in significantly higher quantities than the cyclohexenyl analogue **25**.



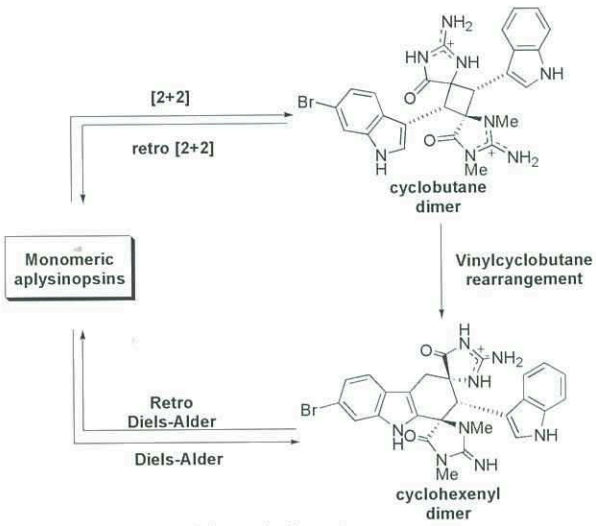
Scheme 2. Vincylcyclobutane rearrangement

An attempt to effect this rearrangement by heating an aqueous solution of pure dictazole A (**28**) to 200 °C in a microwave reactor led to fascinating results. A significant amount of dictazoline C (**25**) was detected by LC-MS along with three monomeric aplysinopsins, presumably arising from a retro-Diels-Alder reaction of **25** (Scheme 3). Disappointingly, owing to a scarcity of natural material, no products could be characterized by NMR nor could the experiments be repeated.[18]



Scheme 3. Retro Diels-Alder fragmentation of dictazoline C

The findings of Williams and co-workers have led to even more unanswered questions. Could the monomeric aplysinopsins undergo conversion to the corresponding cyclobutane dimer in a [2+2]-process? Does the proposed vinylcyclobutane rearrangement to the cyclohexenyl dimer render the Diels-Alder proposal obsolete, or is there a biosynthetic cycle involved that incorporates more than one defined pathway (Scheme 4)? The results from testing the viability of these propositions with labelling studies and chemical syntheses are eagerly awaited.



Scheme 4. Possible biosynthetic cycle.

Concluding Remarks

The fascinating history of the aplysinopsin natural products, from its inception with the isolation of aplysinopsin in 1977 up until the appearance of the dictazoles in early 2010 has been summarized. Upon considering the biosynthetic origin of the cyclohexenyl aplysinopsin dimers, both the Diels-Alder cycloaddition and the vinylcyclobutane rearrangement proposals appear equally feasible. An examination of both compelling biosynthetic pathways through chemical synthesis is in progress in our laboratory and the results will be reported in due course.

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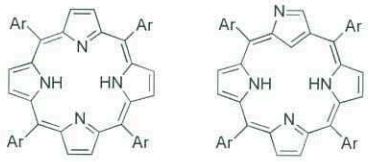
Making Sense of *N*-Confused Porphyrins

Anna Młodzianowska and Penelope J. Brothers

Department of Chemistry, University of Auckland, Private Bag 92019, Auckland 1124
(e-mail: *a.mlodzianowska@auckland.ac.nz*)

Porphyrins (**1**, Chart 1) are organic molecules that act as macrocyclic ligands and are comprised of four pyrrole rings connected by methine bridges. They are most familiarly known as the red pigment in hemoglobin where they serve as oxygen carriers. In this role, the porphyrin coordinates an iron atom in the central cavity in place of the two internal *N*-bound protons, and O_2 is bound to a vacant position on the iron. In the laboratory, tetra-arylporphyrins (**1**, Chart 1) can be easily prepared by a self-assembly reaction involving condensation of four equivalents each of pyrrole and an aldehyde (ArCHO) with subsequent oxidation to the 18 π-electron aromatic macrocycle. Synthetic modifications of porphyrin ligands for a range of different applications in catalysis, medicine, and materials science are well-established, and most elements from the periodic table can be inserted into the porphyrins to form an ever-expanding range of coordination complexes. Most modifications of the porphyrin itself are concerned with different substituents at the *meso*-positions (those occupied by an aryl ring in **1**) or at the β-pyrrolic positions (occupied by H in the five-membered rings of **1**). However, over the last decade, interest in the special properties of porphyrin ligands has extended beyond these simple modifications to a growing family of *porphyrinoid* molecules, which share the essential features of porphyrin, namely pyrrole building blocks and an unsaturated macrocylic framework. This extended family comprises expanded, contracted and isomeric porphyrins. It is the last of these, structural isomers of the familiar porphyrin ring, that are described below with a focus, in particular, on the isomer of regular porphyrin known as the *N-confused porphyrins* **2** (Chart 1).

Chart 1. Porphyrin (**1**) and *N*-confused porphyrin (**2**).

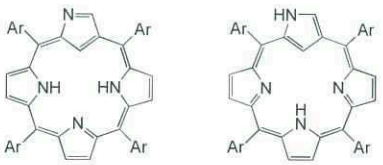


In *N*-confused porphyrin **2** the connectivity, and hence orientation of one of the pyrrole rings is different from porphyrin itself. Normally, each pyrrole is connected into the macrocycle through positions 2 and 5, whereas in *N*-confused porphyrin one pyrrole ring is, instead, connected through positions 2 and 4. This small change causes one of the nitrogen atoms to be located on the periphery of the macrocycle and a carbon atom to be located inside. This has a big influence on the ligand properties, not surprising as instead of the four *N*-donor atoms that occur in porphyrin **1**, the *N*-confused porphyrin **2** has three *N*-donors and a carbon available to coordinate to a central element.

The first example of an *N*-confused porphyrin (5,10,15,20-tetraaryl-2-aza-21-carbaporphyrin, **2**) was published simultaneously by two research groups, Furuta *et al.*[1] in Japan and Latos-Grażyński *et al.*[2] in Poland. They discovered that *N*-confused porphyrin is produced in very low yield (4-7 %) as a by-product in the pyrrole/aldehyde condensation reaction used to form regular porphyrin.[3] An optimized synthetic route subsequently was published by Lindsey.[4]

N-confused porphyrin can exist as two tautomers, depending on the solvent (Chart 2). Tautomer **2a**, observed in dichloromethane, has three inner protons, two NH and one CH. The second tautomer **2b**, which occurs in *N*,*N*-dimethylformamide, has one CH and one NH proton inside the macrocycle and one NH proton located outside. These tautomers are readily distinguished by their significantly different UV-visible and NMR spectra, as well as from the colours of the compound in different solvents.[5] From experimental observation, tautomer **2a** was found to be the most stable and this was confirmed by DFT studies.[6,7]

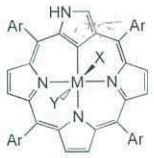
Chart 2. Tautomeric forms of *N*-confused porphyrin.



The proton NMR spectrum of *N*-confused porphyrin **2** is very different from that of regular porphyrin **1** that has idealized D_{4h} symmetry and so a very simple spectrum in which, for example, the resonance for the eight β-pyrrole protons appears as a singlet. *N*-confused porphyrin has no symmetry (C_1), so that a unique signal is observed for each β-pyrrole proton and the inner CH and NH protons.

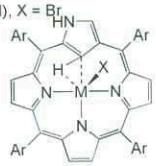
Depending upon which tautomer is involved in metal coordination, *N*-confused porphyrin can be a dianionic or trianionic ligand and can form different types of metal complexes. The first group of complexes comprises compounds containing a covalent M-C(21) bond between the metal and the inner [C(21)] carbon, in which the *N*-confused porphyrin is a dianion based on tautomer **2b** and bears an external NH. For example, these types of metal complexes are observed for all three of the group 10 metals Ni(II) **3d**, Pd(II) **3e** and Pt(II) **3f** as well as a range of other main group and transition metal ions **3a-n** as shown in Chart 3.[8-17] The second class of complexes also contains a covalent M-C(21) bond, but the external nitrogen on the ligand is not protonated, and the ligand coordinates as a trianion in the tautomer **2a** form, *e.g.* Ag(III) **4a**, Cu(III) **4b**, as well as **4a-g** in Chart 3.[9,10,17-22] The third and fourth group of metal complexes contain an agostic bond between M and H-C(21), in which C(21) retains its H substituent and the metal centre interacts with the C-H bond, occurring in the **2a** dianionic forms **5a-d**,[9,15,23] or the **2b** trianionic forms **6a-c**,[24-26] (Chart 3).

Chart 3. Metal complexes of *N*-confused porphyrin.



3a: M = Co(II), X = py, NH = NCH_2CO_2Et
3b: M = Cu(II)
3c: M = Cu(II), NH = NMe
3d: M = Ni(II)
3e: M = Pd(II)
3f: M = Pt(II)
3g: M = Mn(II), X = Br
3h: M = Ni(III), X = Br
3i: M = Ni(III), X = NO_3
3j: M = Ni(III), X = OH
3k: M = Ni(III), X = H_2O
3l: M = Ni(III), X = Y = CN
3m: M = Sn(IV), X = Cl
3n: M = Sb(V), X = Br

4a: M = Ag(III)
4b: M = Cu(III)
4c: M = Mn(III), X = py
4d: M = Mo(III), X = pip
4e: M = Sb(V), X = Br
4f: M = Sb(V), X = OMe
4g: M = Sb(V), X = OEt

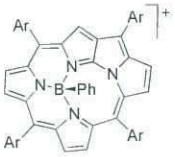


5a: M = Cu(II), X = Cl
5b: M = Fe(II), X = Br
5c: M = Fe(II), X = S-*p*-Tol
5d: M = Mn(II), X = Br

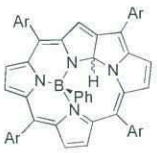
6a: M = Mn(II), L = py
6b: M = Yb(III), L = $(\eta^5\text{-}C_5H_5)Co[P(=O)(OMe)_2]$
6c: M = Er(III), L = $(\eta^5\text{-}C_5H_5)Co[P(=O)(OMe)_2]$

The examples given above primarily involve transition metals as well as two examples each of lanthanides Yb and Er,[25,26] and the heavier main group elements Sn and Sb.[16,17,22] The smaller, lighter main group elements boron and phosphorus yield further unusual structural types of porphyrin-like complexes. The reaction of $PhBCl_2$ with *N*-confused porphyrin yields two types of monoboron complexes, **7** and **8**. Both of them have *N*-fused rather than *N*-confused porphyrin skeletons.[27] The *N*-fused porphyrin skeleton features one pyrrole α-carbon, which has bonds to two pyrrole nitrogens. The addition of PCl_3 to *N*-confused porphyrin yields phosphorus(V) complex **9**, also containing the *N*-fused porphyrin skeleton.[28] Compounds **7-9** have subtle differences, including their charge, and the ligands occur as monoanion, dianion and trianion, respectively. The ligand in complex **7** is a true *N*-fused porphyrin, which is two oxidation levels higher than a porphyrin. The ligands in **8** and **9** are tautomers, but are formally at the same oxidation level as porphyrin, which means they are further examples of structural isomers of porphyrin and *N*-confused porphyrin.

Chart 4. Boron(III) and phosphorus(V) complexes.



7



8

9

What is the outlook for these new members of the porphyrin family? In fact, they are not all that new as they comprise by-products from porphyrin syntheses, but the recent focus on their chemistry has opened up some new possibilities. Firstly, the notion of a porphyrin isomer capable of forming a trianionic ligand has proved useful for stabilizing complexes of transition metals in higher oxidation states and also in unusual coordination geometries.[29,30] Examples of less common high oxidation states stabilized by coordination to *N*-confused porphyrin are the Ni(III) **3h-l**, Ag(III) **4a** and Cu(III) **4b** complexes listed in Chart 3.[10-12,18,19] Porphyrins and their expanded and contracted isomers are being widely used in supramolecular architectures of all kinds, and the isomeric analogues are also being explored for these applications. Materials science applications utilize their strong light-absorbing properties and the *N*-confused and *N*-fused porphyrins add further members with different symmetries and electronic excited states to this family of chromophores. Last but not least, they are adding to our fundamental knowledge of the chemistry of the porphyrin core itself, which despite being familiar and widely utilized now has structural isomers established as an integral part of its chemistry, along with many new metal complexes.[31]

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Compulsory Licensing in a Nutshell

Tim Stirrup and Katherine Hebditch

Baldwins Intellectual Property, PO Box 5999, Wellesley St, Auckland (email: *tim.stirrup@baldwins.com* or *katherine.hebditch@baldwins.com*)

It would seem inconceivable that a government or competitor could ride roughshod over your hard-earned patent rights. Surely the right to exclusively exploit your invention is enshrined in law and international agreements? In exceptional circumstances this is exactly what can happen, and every major patent system in the world has provisions for the government or a court to intervene and grant a competitor the right to use the invention without the patentee's permission. These are known as compulsory licences and although the patent owner should still receive royalty payments, they are still a serious issue for patentees. While there may be a perception that the use of compulsory licensing is the domain of left wing governments sporting anti-capitalist, anti-imperialist ideologies this is not necessarily the case.

How are they granted?

World Trade Organisation (WTO) agreements dictate that compulsory licences may be granted where an invention is not being made available to the market in a country on reasonable terms, or not being made available at all. Alternatively, they may be granted in cases of national emergency or situations of extreme urgency.

Pharmaceuticals are most commonly associated with compulsory licensing provisions and have been the subject of a number of major cases in which negotiations over the price of patented pharmaceuticals have broken down and led to a compulsory licence being granted.

However, although many developing countries may have public health emergencies that could justify the grant of a compulsory licence, the reality is that they often lack the capability to manufacture high grade pharmaceuticals. In recognition of this fact, the WTO declared in 2003 that compulsory licences may be legitimately granted in developed countries to respond to public health emergencies in designated countries, with a particular emphasis on the least developed countries of the world.

Public health emergencies

While a compulsory licence has never been granted in New Zealand, the emergency/urgency provisions were put into practice in Canada in 2006. In this case, the Canadian government licensed the company Biolyse to produce and export a generic version of the drug Tamiflu (used to treat avian influenza or bird flu). The action was taken by the government on the premise that Roche (the patent owner) could not produce enough of the drug to meet potential demand in Canada or in the least developed countries in the event of a bird flu epidemic. However, these decisions are rarely taken solely on the basis of a lack of supply of a treatment for a potential public health crisis. Political and financial interests are often also very much to the fore.

In the face of a growing incidence of HIV/AIDS, Thailand granted a compulsory licence for the anti-retroviral (ARV) Efavirenz in 2006. It is estimated that this decision enabled the Thai government to save US$23 million per year over 5 years.[1]

Soon after, Brazil followed suit by issuing a compulsory licence for the import of a generic version of Efavirenz from India and in early 2010 Brazil started producing the drug locally. The Brazilian decision came after rejecting Merck's offer to lower the price from US$1.57 per dose to US$1.10 per dose. Instead Brazil demanded a cost of US$0.65 per dose, which was the offer made to Thailand. Indian generics were available at US$0.43 so the decision to grant a compulsory licence was made and resulted in an estimated US$30 million saving to the Brazilian government in 2007.[2]

The repercussions of grant

Although the issuing government may save millions on healthcare costs, the grant of a compulsory licence is often an action of last resort which must be weighed against the potential repercussions from trading partners and other countries. These repercussions can take the form of increased trade barriers and diplomatic pressure from governments and the pharmaceutical industry. Following the Thai decision to grant a compulsory licence the USA apparently retaliated by adding Thailand to its *Priority Watch List* and increasing import tariffs for a number of Thai exports to the USA.[3]

Retaliatory measures can seem hypocritical in the face of similar actions being taken by those same governments. For example soon after the Anthrax scare in 2001 the threat of a compulsory licence being granted in both Canada and the USA was enough to persuade Bayer to reduce the price of the antibiotic Ciprofloxacin from $1.77 per tablet to $0.95 and resulted in a saving to the US government of at least US$82 million.[4]

The USA has also granted what are, effectively, compulsory licences in numerous rulings. Since June 2006, the courts have issued decisions that have benefitted Microsoft[5] (on DRM technology patents), Toyota[6] (patent on automatic transmission system), and Direct TV[7] (set-top boxes) among others. In these cases, the courts have allowed continued infringement of the patent in return for court-ordered royalty payments to the patentee.

Compulsory licensing as a negotiating tool

Although the actual instances of compulsory licensing are few and far between, the real power of the compulsory licensing provisions lies in their use as a negotiating tool to drive down prices and promote competition. The use of this tool has been used to provide huge numbers of HIV/

AIDS sufferers with treatment that they might otherwise have been unable to afford.

The benefits to public health of using compulsory licensing as a negotiation tool must be weighed against the negative effects that would occur if compulsory licensing were to be abused and become commonplace. Such a culture of disrespect for intellectual property would be a severe impediment to the development of domestic research and development and result in severe trading sanctions from developed nations.

The grant of compulsory licences in any country is an area of patent law that provokes intense debate. On the one hand is the need for patent owners to be able to dictate the terms on which their inventions are used so they can recoup the costs of research and development. On the other hand is the need for governments to reduce costs and provide access to patented technologies that may be the difference between life and death. As the complexity and diversity of medicines continues to increase, as well as the prevalence of diseases such as HIV/AIDS, it appears that compulsory licensing will continue to be used to influence the terms of international trade for the foreseeable future.

If you have any queries regarding intellectual property related matters (including patents, trademarks, copyright or licensing), please contact us: *tim.stirrup@baldwins.com* or *katherine.hebditch@baldwins.com*

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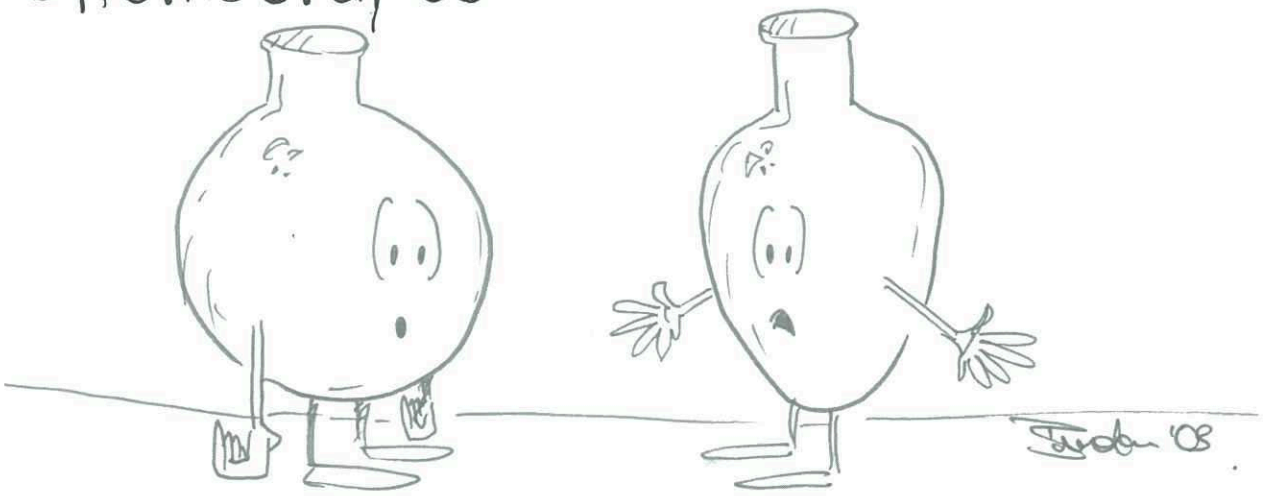
Katherine Hebditch and Tim Stirrup of Baldwins Intellectual Property in Auckland specialise in chemistry and biotechnology patents. Katherine obtained her PhD in organic chemistry from the University of Manchester in the UK in 2004. She is currently working towards registration as a patent attorney. Tim obtained his PhD in molecular biology from the University of Southampton in the UK in 2007. He is also working towards registration as a patent attorney.

ChemScrapes



- Everything was fine... then it suddenly went all pear-shaped.

Brendan Burkett

Dates of Note

July 28 is the sixth anniversary of the death of Nobel Laureate and DNA structure giant *Francis* ***Crick***. Distinguished crystallographer *Dorothy* ***Hodgkin***, born in 1910, died on 29 July 1994. *Jean Antoine Claude* ***Chaptal*** was the French chemist who wrote the first book on industrial chemistry and coined ***nitrogen*** as the name for the gas; he died on 30 July 1832. *Stephanie Louise* ***Kwolek***, the Polish-American chemist who invented poly-paraphenylene terephtalamide – *Kevlar*, was born on July 31, 1923. The day also marks the 210th anniversary of the birth of *Friedrich* ***Wöhler***; he died on Sept 23, 1882.

Otto Heinrich ***Warburg*** was a German biochemist awarded the Nobel Prize for Physiology or Medicine in 1931 for his research on cellular respiration, the process by which substances directly supplied to cells (or stored in them) are broken down into simpler components while using oxygen. August 1 marks the 40th anniversary of his death. The French chemist *Joseph-Achille* ***Le Bel*** was the first to present a theory on the relationship between molecules and how they absorb or reflect light. The 80th anniversary of his death is on August 6. *Viktor* ***Meyer***, whose apparatus continues to be used to measure vapour densities, died on 8 August 1897.

John Ulric ***Nef***, the Swiss-American chemist demonstrated that carbon can have a valence of two as well as a valence of four thereby advancing the understanding of theoretical organic chemistry. He provided a basis for the modern system of chemical notation and has a reaction named after him. He died 95 years ago on Aug 14. Biochemist *Sune K.* ***Bergström*** who shared the 1982 Nobel Prize for Physiology or Medicine died 6 years ago on Aug 15. Aug 16, 1957 saw the death of *Irving* ***Langmuir***, the American physical chemist whose studies of molecular films on solid and liquid surfaces opened new fields in colloid research and biochemistry and won him the Nobel Prize for Chemistry in 1932; Langmuir-Blodgett films need little introduction these days. The same day marks the 7 years since Element 110, *Darmstadtium* was officially named.

Lothar ***Meyer*** independently discovered the Periodic Law of *Dmitry* ***Mendeleyev*** at about the same time in 1869. He was born on Aug 19, 180 years ago. *Johan Gottlieb* ***Gahn*** was born on the same day 265 years ago (1745). He was a Swedish mineralogist and crystallographer, who improved smelting methods at the copper mine in Falun, and discovered both manganese and selenium. This same day is the 16th anniversary of *Linus* ***Pauling***'s death and the 245th since *Axel Fredrik* ***Cronstedt*** died (1765). He was another Swedish chemist and metallurgist and the first to isolate nickel (1751) and notice its slight magnetic properties. A (new) chemical classification of minerals he made was translated into several languages.

Aug 23 is the 77th birthday of *Robert F.* ***Curl***, who with Smalley and Kroto discovered C_{60}, the first fullerene, in 1985. On the same day 125 years ago, Sir *Henry* ***Tizard*** was born. He was the English chemist, inventor and administrator whose work around 1920 (with David Pye) ultimately led to the octane anti-knocking rating system. *Sir Hans Adolf* ***Krebs*** (of Krebs cycle fame) was born on Aug 25 in 1900. Aug 26th is the 23rd anniversary of *Georg* ***Wittig***'s death while the 27th marks 135 years since the discovery of gallium by *P.E.* ***Lecoq de Boisbaudran*** from a 52 kg mineral sample taken from the Pierrefitte mine in France. *E.M.* ***Purcell***, the American physicist who shared (with Bloch) the Nobel Prize for Physics in 1952 for his independent discovery (1946) of nuclear magnetic resonance in liquids and in solids, was born on Aug 30, 1912. Sir *Ernest* ***Rutherford*** was born on 30 Aug 1871 and died on Oct 19, 1937. Sir *George* ***Porter***, the distinguished English photochemist and Director of the Royal Institution, died 7 years ago on Aug 31.

The little known *Phoebus* ***Levene*** was a Russian-born American chemist and pioneer in the study of nucleic acids. In 1909, he found that the carbohydrate present in nucleic acid from yeast is ribose and, in 1929, he identified the carbohydrate in the nucleic acid from the thymus of an animal. It is also a pentose sugar but lacks one oxygen atom of ribose and was, therefore, called deoxyribose; they were named ribonucleic and deoxyribonucleic acids (RNA and DNA). Later discoveries showed them to be key elements in the maintenance of life. He died 70 years ago on Sept 6. Military explosives expert and chemist Sir *Frederick* ***Abel*** died on the same day in 1902.

Sir *John Warcup* ***Cornforth***, the Australian chemist who shared the 1975 Nobel Prize for Chemistry (with Prelog) for his work on the stereochemistry of enzyme-catalyzed reactions, will celebrate his 93rd birthday on Sept 7. The same day marks the 25th anniversary of the death of *Rodney* ***Porter***, the British biochemist who (with Edelman) was awarded the 1972 Nobel Prize in Physiology or Medicine for discoveries concerning the chemical structure of antibodies. On Sept 8, 1980 *Willard Frank* ***Libby***, the American chemist who established carbon-14 (radiocarbon) dating and was awarded the 1960 Nobel Prize in Chemistry, died, as did polymer pioneer *Hermann* ***Staudinger*** in 1965.

John ***Kidd*** was the English chemist and physician who obtained naphthalene in 1819 and gave it its name. In addition to teaching chemistry at Oxford, he was elected (1803) as the first Aidrichian professor of chemistry, he later taught mineralogy and geology. His geology students included William Conybeare, William Buckland and Charles Daubeny. Holding a medical degree, he also taught anatomy (from 1816) and medicine (from 1822). He wrote a pamphlet on the role of science in education. He was born on Sept 10, 1775 and died on Sept 17, 1851.

Sept 25, 2010 marks the 25th anniversary of the death of *William Cumming* ***Rose***. He was an American biochemist who researched the role of amino acids in nutrition, determining which were essential, and calculated the minimum daily requirement for each of them. Having found that the

milk protein, casein, was essential in a healthy rat's diet, he discovered (1936) the threonine in the casein was an essential amino acid. Over several years he established the primary importance of nine more amino acids, namely lysine, tryptophan, histidine, phenylalanine, leucine, isoleucine, methionine, valine, and arginine.

Frenchman *Bernard* ***Courtois*** died on Sept 28, 1838. The son of a saltpeter manufacturer from Dijon, he grew interested in chemistry, was apprenticed to a pharmacist and became the first to isolate pure morphine from opium in 1804. He also discovered the element iodine. This same day marked the death of *Louis* ***Pasteur*** in 1895. The last day of September is the 67th birthday of *Johann* ***Deisenhofer*** (the German biochemist who shared the 1988 Nobel Prize in Chemistry with Michel and Huber for protein structure) and the 71st of *Jean-Marie* ***Lehn***, often a visitor to NZ and Otago in particular.

New Zealander *Maurice* ***Wilkins*** died 6 years ago on Oct 5. He shared the 1962 Nobel Prize for Physiology or Medicine (with Watson and Crick) for their X-ray diffraction studies of deoxyribonucleic acid (DNA). Sir *Harry* ***Kroto***, MacDiarmid Board Member and 1996 Chemistry Nobel Laureate, has his 71st birthday on Oct 7. The day also marks the 125th anniversary of *Neils Henrik David* ***Bohr***'s birth; his fame was with quantum theory.

Paul Hermann ***Müller***, the Swiss chemist who received the Nobel Prize for Physiology or Medicine in 1948 for discovering the potent toxic effects on insects of DDT, died 45 years ago on Oct 12. ***Nobel***'s first patent for the production of nitroglycerine was issued on Oct 14, 1863 in Sweden. *Konrad Emil* ***Bloch***, the German-born American biochemist who shared the 1964 Nobel Prize for Physiology or Medicine (with Lynen) for discoveries concerning the natural synthesis of cholesterol and fatty acids, died ten years ago on Oct 15, the same day as *Herbert Henry* ***Dow*** in 1930, the pioneer of US chemical industry.

On October 16, 2006, researchers from JINR and Lawrence Livermore National Laboratory of California, USA, working at the JINR in Dubna, announced that they had indirectly detected a total of three (possibly four) nuclei of *ununoctium-294* (one or two in 2002 and two more in 2005), the heaviest element yet. It was produced *via* collisions of californium-249 atoms and calcium-48 ions. The same day in 1846 saw the first demonstration of ether anesthetic by dentist Dr *William Thomas Green* ***Morton***.

The German-Swiss chemist who discovered and named ozone (1840) and was the first to describe guncotton (nitrocellulose), *William* ***Cookworthy***, died on Oct 17, 1780. *Lewis Frederick* ***Urry***, the Canadian-American chemical engineer who invented the alkaline and lithium batteries, died on Oct 19, six years ago. On the same day in 1875 Sir *Charles* ***Wheatstone*** died; he popularized the Wheatstone bridge.

£1 million prize for the first 100% chemical free product!

The UK Cosmetic, Toiletry and Perfumery association (CTPA) is an association of manufacturers of cosmetic, toiletry and perfumery products. It was founded in 1945 and launched a new addition to its website (http://www.thefactsabout.co.uk/) entitled *Facts about Chemicals* in February of this year, in conjunction with the Royal Society of Chemistry (RSC). The aim of the *Facts about Chemicals* site is to answer consumer and media questions about chemicals in cosmetic and personal care products.

We have all heard media claims that you can buy household cleaning products, shampoos and foods that claim to be *chemical free* or *do not contain any nasty chemicals*. As we know there is no such thing as a 'chemical free' product as it is impossible to achieve. The CTPA, therefore, works with the manufacturers of cosmetic and personal care products to encourage them not to use these terms when advertising their products to consumers.

In February of this year the RSC announced it would give a prize of £1 million pounds to anyone who could create what the RSC would consider to be a 100% chemical free product.

Dr Richard Pike the Chief Executive of the RSC states:

> *If products are marketed as 'chemical-free' as though that's not only possible, but actually desirable, it's no wonder some consumers might feel concerned about the safety of chemicals. To raise awareness of how impossible 'chemical-free' is as a claim, I'm challenging anyone to place in my hand a product I consider to be chemical-free. The truth, as any right-minded person will say, is that everything we eat, drink, drive, play with and live in is made of chemicals – both natural and synthetic chemicals are essential for life as we know it.*

This is the second time this challenge has been issued by the RSC as it tried to re-claim the word *chemical* in October 2008. This followed claims from a popular fertilizer manufacturer who advertised that its product contained *no chemicals whatsoever.*

In relation to the launch of the new website page Dr Pike said: *It will help to reduce some of the confusion about chemicals so that people can make better-informed decisions and choices in their daily lives. Any measures industry can take to promote a more science-based understanding of chemicals, and the very positive role they play in our everyday lives, can only be a good thing.*

Anthea Lees

Conferences

60th Anniversary Conference on Coordination Chemistry (60CCCO), 27-30 September 2010, Osaka, Japan

Deadline for abstract submission: July 23rd 2010

http://www.sakutai.jp/index.eng.html

Polymer Chemistry Conference 2010, 18-21 November 2010, Puerto Morelos, Mexico, North America

This conference will focus on polymer chemistry and materials science applied to biological problems of current relevance.

http://www.zingconferences.com/index.cfm?page=conference&intConferenceID=66&type=conference

MM 2010 molecular modelling for life and material sciences, Melbourne, 28 November - 1 December 2010, Australia

This meeting will focus on the latest developments in molecular modelling in both the life sciences and materials sciences, particularly in the areas of drug development, nanotechnology, biophysical modelling and methods and algorithms.

http://mm2010.org/

Organic Synthesis: A Toolkit for the Industrial Chemist, 1-3 December 2010, Barcelona, Spain

This 3-day course, written and presented by highly experienced chemists from the pharmaceutical and fine chemical industry, provides a modular overview of the most important tools available for the organic chemist working in industry.

http://www.scientificupdate.co.uk/training/scheduled-courses/details/92-organic-synthetic.html

11th European Meeting on Environmental Chemistry, 8-11 December 2010, Portorož, Slovenia

Conference topics are: Emerging contaminants, Atmospheric chemistry, Water treatment and waste management, Analytical methods for environmental science, Soil chemistry, Pollutant chemistry, Aquatic and marine chemistry, Biogeochemistry, Clean technologies and green chemistry, Ecotoxicology, Biomarkers.

http://sabotin.ung.si/~emec11/

Biocatalysis Conference, 10-13 December 2010, Puerto Morelos, Mexico, North America

This conference will cover recent developments in biocatalysis in both academia and industry including topics such as enzyme discovery, directed evolution of enzymes, scale-up of biocatalytic processes, novel screening methods, metagenomics, pathway engineering and other areas of related research.

http://www.zingconferences.com/index.cfm?page=conference&intConferenceID=69&type=conference

5th International Conference on Advanced Materials and Nanotechnology - AMN-5, 7-11 February 2011, Wellington, New Zealand

The biennial conference offers a broad interdisciplinary overview of advanced materials and nanotechnology, and provides an exciting forum to discuss new and exciting advances in the field

Abstracts can be submitted from 1 July 2010 to 31 August 2010.

http://www.confer.co.nz/amn-5/

5th International Congress of Chemistry and Environment (ICCE 2011), May 27-29 2011, Kuching, Sarawak, MALAYSIA

http://www.chemistry-conferences.com/2011/05/27%20-%2029%20Conference%20of%20Chemistry%20and%20Environment%20(Kuching%20-%20MY).htm

www.accc3.org

2012 International Symposium on Macrocyclic and Supramolecular Chemistry (ISMSC-2012), 29 January - 2 February 2012, University of Otago, Dunedin, New Zealand

Register interest via: *www.otago.ac.nz/ismsc2012/*

CHEMICAL EDUCATION TRUST

Applications are invited from secondary school teachers (via the Head of Science) for grants from the ***NZIC Chemical Education Trust*** to promote the teaching of chemistry in their school. For the 2010 distribution, grants of around $500 are envisaged, but greater or lesser amounts can be applied for.

Closing date for applications: 1 August 2010

Applications must include full details of the item(s) for which funding is requested together with an up-to-date quotation, email contact and full postal address.

Send your application to: Professor Andrew. Brodie,
NZIC Chemical Education Trust,
Institute of Fundamental Sciences,
Massey University,
Private Bag 11-222, Palmerston North 4442.
Fax: 06 350 5682; e-mail: *A.Brodie@massey.ac.nz*

Applications that arrive after the closing date or do not include full details, as listed above, will not be considered.

Grants and Scholarships

The Prime Minister's Science Prizes

The Prime Minister's Science Prizes recognise the impact of science on New Zealanders' lives. They are an opportunity for the people of New Zealand to celebrate the contribution of our current scientists and to encourage those of the future. The Prizes will highlight the significance of science by telling the story of our successes and achievements.

1. The Prime Minister's MacDiarmid Emerging Scientist Prize: $200,000
2. The Prime Minister's Science Teacher: $150,000
3. The Prime Minister's Future Scientist Prize: $150,000
4. The Prime Minister's Science Media Communication Prize: $100,000

Deadline: 27 August, 2010.

The 2010 Future Scientist Prize will be awarded to the Supreme Award recipient from the Royal Society of New Zealand's 'Realise the Dream' competition. Judging for the Prime Minister's MacDiarmid Emerging Scientist Prize is currently underway.

http://www.pmscienceprizes.org.nz/news/100519_2010_prize_round_announced.html

For further information please contact:
Rebecca Goffin, Royal Society of New Zealand, The Prime Minister's Prizes Project Manager. Email: Rebecca.Goffin@royalsociety.org.nz

Primary Science Teacher Fellowships

A six-month fellowship designed to create potential science curriculum leaders in the primary sector. This is done through placement for six months in a scientific organisation learning how science is applied outside of schools, intensive curriculum support and leadership training. This is a fellowship which aims to create potential curriculum leaders in Science for the primary sector. If you have been teaching for three or more years, have an interest in up-skilling in science, and are keen to undertake a leadership role in your school in Science education, this may be the fellowship for you.

Deadline: 17 September 2010 for Fellowships beginning term 1 2011

http://www.royalsociety.org.nz/Site/teachersstudents/Funding_for_teachers/teacher_fellowships/primary-science.aspx

Conventions and Incentives New Zealand Conference Assistance Programme

This programme is to provide assistance for bidding to host an international conference in New Zealand. This can include discounted airfares to travel to present a bid, help to write bid documents and accompanying marketing material, as well as other assistance.

For further details see the website:

http://www.conventionsnz.com/cap.aspx

Foundation of Research, Science and Technology

This has a number of on-demand schemes that provides funding to enable businesses to develop new research and development projects. There are a number of different options available.

The following website has a table with how often these on-demand schemes are considered for funding and further details about the various schemes.

http://www.frst.govt.nz/investframe/process/ondemand

New Zealand Trade and Enterprise International Growth Fund

The fund is targeted at businesses New Zealand Trade and Enterprise (NZTE) is working closely with on a plan to help them develop and grow. These are businesses that NZTE has assessed as being most likely to contribute to New Zealand's long-term growth, including through success internationally in the short to medium term. Businesses that receive funding need to at least match the level of investment that NZTE makes through the fund. All investments from the fund are at NZTE's discretion and there is no guarantee a business will get financial support.

http:www.nzte.govt.nz/find-funding-assistance/Pages/International-Growth-Fund.aspx

New Zealand Trade and Enterprise Capital raising advice and assistance

This service provides assistance to any business or entrepreneur who needs to raise funds to expand, diversify or commercialise a new concept.

For further details see the website:

http://www.nzte.govt.nz/find-funding-assistance/capital-raising-advice-and-assistance/pages/capital-raising-advice-and-assistance.aspx

Rutherford PhD scholarships at Cambridge University

These scholarships are for applicants undertaking full-time study towards a PhD at Cambridge University in pure or applied science. The Rutherford Scholars receive an allowance of approximately £10,500 for up to three years as well as university and college fees and one return airfare between New Zealand and the United Kingdom.

Closing date for applications is 30 July 2010

For further details see the website:

http://www.royalsociety.org/Site/rutherford/guidelines.aspx

Phar Lap and synchrotron radiation: What's the connection?

One of the world's most famous race horses 'Phar Lap' was born in New Zealand (in Seadown near Timaru) and his life and infamous death in 1932 have been widely tabulated. He died after winning the world's richest race of that time, the Agua Caliente Handicap in Mexico, in what were then, considered to be, very suspicious circumstances. Rumours of foul play at the time, including arsenic poisoning, were reported but the actual cause of death was never fully established. Following his death, his mounted hide was displayed at the Melbourne Museum; his skeleton was sent to the Museum of New Zealand Te Papa Tongarewa while his heart is displayed at the National Museum of Australia in Canberra.

A paper recently published in Angew. Chem. Int. Ed. (2010, 49, 4237-4240) by Ivan Kempson and Dermot Henry, looks at a possible theory behind the death of this famous horse. Researchers took a number of hairs from Phar Lap's hide and analysed them for arsenic poisoning. If Phar Lap was indeed poisoned, then any record of this poisoning could be recorded along the length of the strands of his hair. It should however be noted that arsenic was also used to preserve Phar Lap's hide after his death. It is, therefore, important that the arsenic used in the preservation of the hide should be distinguishable from any arsenic which may have been ingested by the horse while he was alive.

Hairs, which were known to be actively growing at his death, were chosen from his hide and were analysed using a synchrotron X-ray-fluorescence microprobe (XRF). The XRFs technique was used to longitudinally map four of the hairs for elemental analysis and the arsenic map produced from this analysis showed the presence of low concentrations of arsenic throughout the hair. However in the subcutaneous region (area just below the skin) an intense band (which occurred at the same location in each hair) was observed, which suggested a sudden increase and then quick decay following ingestion and subsequent excretion of arsenic. To look at the chemical environment of the arsenic, X-ray absorption near edge spectroscopy (XANES) was performed on the same samples along the arsenic rich region. Two arsenic species were observed: an As^{III} thiol complex and arsenate. The results obtained suggested that arsenic may have been ingested in the form of a complex such as arsenic glutathione. It was also noted that the ingested arsenic did not undergo significant photoreduction but, that arsenic associated with the taxidermy process was degraded from arsenate to arsenite.

This research provides evidence for the differences between any arsenic which had entered the hair cells via the blood and arsenic which had infused into the hair cells by the taxidermy process when the body of Phar Lab was preserved at the museum. The real reason behind Phar Lap's death may never be known but it is known that horses at that time were subjected to ointments and tonics which contained arsenic and strychnine which leads to the possibility of his death being due to an accidental overdose.

On 25th November 2009, a life sized bronze statue of Phar Lap was unveiled at Phar Lap raceway in Timaru to recognize this outstanding thoroughbred.

Anthea Lees

Promoting Scientific Exchange in the Pacific Basin for a Healthy and Sustainable Future

15 - 20 December 2010

Conference Update

The conference will be held at the Hawaiian Convention Center and the beachfront Hilton, Sheraton, Royal Hawaiian; and Westin Moana Surfrider hotels.

The abstract submission phase has closed, program schedule been published and acceptance notices will be posted in the next few weeks. There have been over 13,000 abstracts submitted for the conference.

Entries for the student poster competition will be pre judged and the 200 selected finalists will be informed in Oct/Nov 2010.

Booking for accommodation is now open. Registration for the conference will open in June 2010.

For more details see: *http://www.pacifichem.org/*

For informal information and general background please contact the NZIC representative on the organizing committee: Prof Rob Smith, Chemistry Department, University of Otago, Dunedin - 03 4797924; *rajsmith@chemistry.otago.ac.nz*

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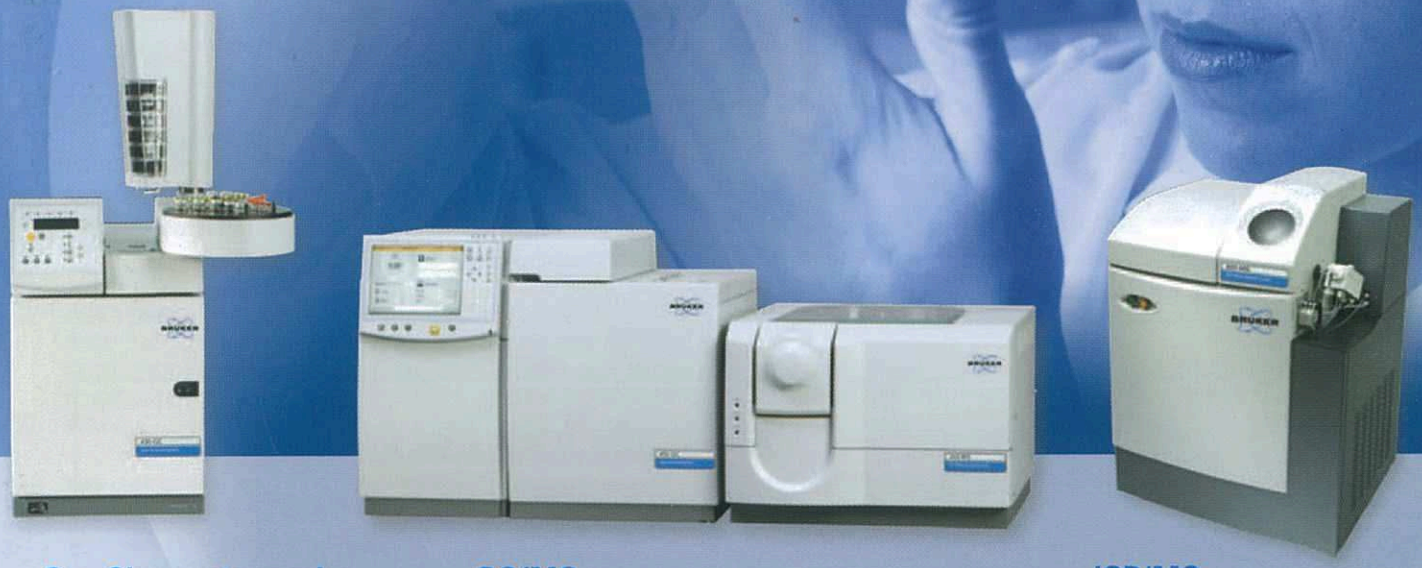

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