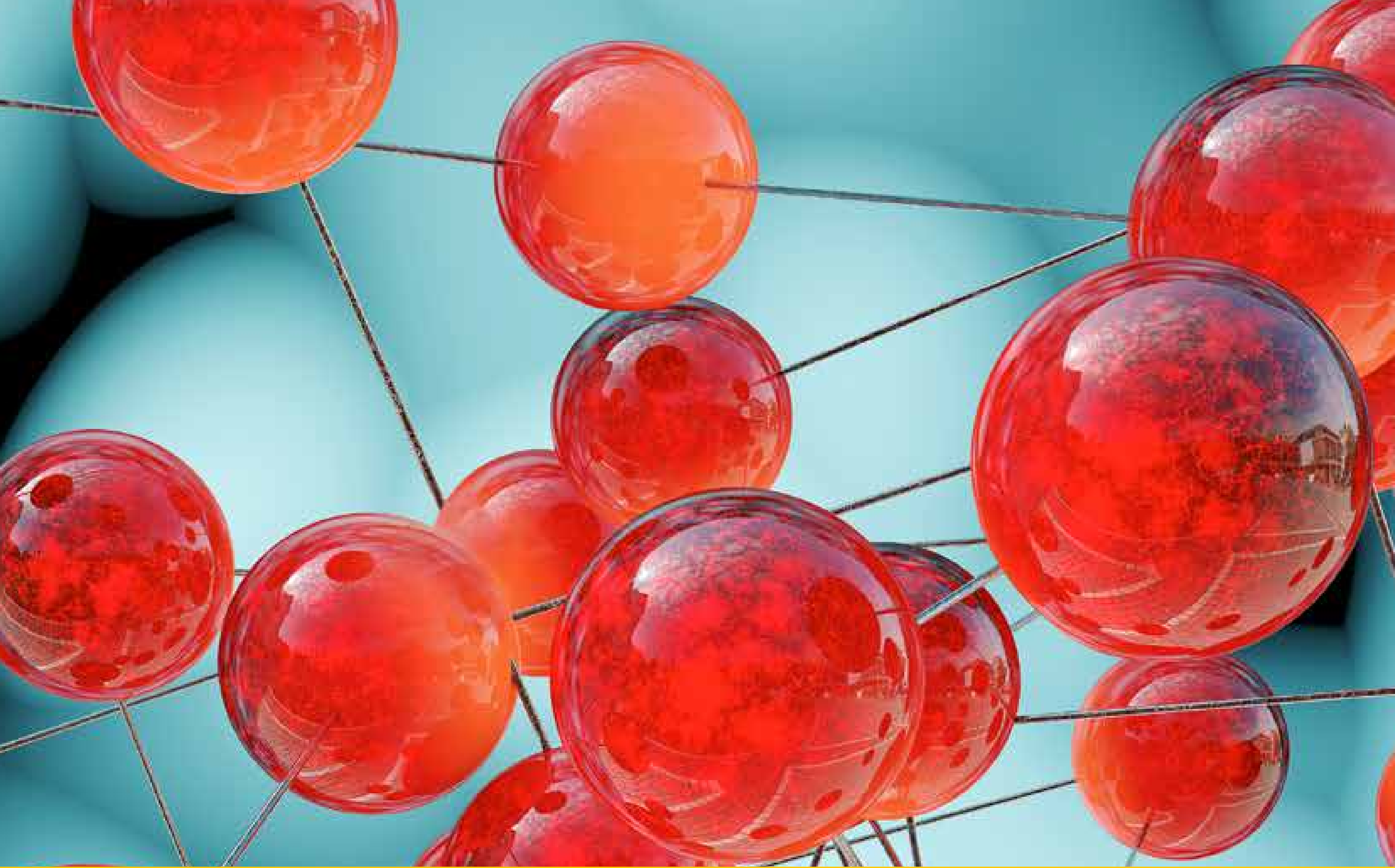


UNSW
THE UNIVERSITY OF NEW SOUTH WALES

Centre for Advanced Macromolecular Design
2014 Annual Report

Never Stand Still

Centre for Advanced Macromolecular Design

Mission Statement

"The Centre for Advanced Macromolecular Design (CAMD) is a research centre in the School of Chemical Engineering and the School of Chemistry at the University of New South Wales that is dedicated to the synthesis and application of polymers/polymeric nano-objects using a wide range of modern polymerization techniques.

A significant portion of CAMD's activities are directed towards general and specific applications in the areas of advanced materials, as well as polymers for energy, sustainability and health/bio applications."

Objectives

To continue to be recognised as a world leader in macromolecular chemistry and employ macromolecular science to address problems in the areas of advanced materials, energy, sustainability and human health.

To further the fundamental understanding of polymerization processes for the optimization of synthetic polymer protocols.

To produce high quality research leading to publications in high impact journals.

To attract and train outstanding PhD students.

To provide a work environment that encourages high quality research.

To attract high quality industry partners and help solve important problems.

To work at the interface of nanotechnology and polymer science.

Steering Committee

Prof. Graham Davies (Presiding Dean)
Dean of Engineering

Prof. Martina Stenzel (co-Director)
School of Chemistry

Prof. Per Zetterlund (co-Director)
School of Chemical Engineering

Prof. Vicki Chen
School of Chemical Engineering (HoS)

Prof. Barbara Messerle
School of Chemistry (HoS)

Prof. Peter Steinberg
School of Biological, Earth &
Environmental Sciences
Centre for Marine Bio-Innovation Sydney
Institute of Marine Science (Director)

Dr. Istvan Jacenyik (Manager)
School of Chemical Engineering

Prof. Peter Lovibond
Senior Associate Dean (Faculty of
Science)

Directors Report

The Centre for Advanced Macromolecular Design (CAMD) focuses on the synthesis of polymers for advanced applications. This broad research field encompasses the development of new polymerization techniques to create polymers/polymeric nano-objects for applications mainly in the areas of advanced materials, health and energy/environment.

The year 2014 was a year of changes. In the beginning of the year, Prof Martina Stenzel took up a position in the School of Chemistry, allowing the centre now to span across two faculties. This will facilitate collaborations between the School of Chemistry and the School of Chemical Engineering. We also welcomed a new member, Dr Pu Xiao, who joined the School of Chemistry as DECRA Fellow. Dr Xiao is an expert in the area of photopolymerization, and he will focus on the development of novel nanodiamond-polymer hybrid materials.

The year 2014 was also another successful year for CAMD. The centre has been highly productive, publishing 66 papers or book chapters in leading international journals, including high impact publications such as papers in JACS and Chemical Sciences. This is the highest research output in CAMD's 14 year history. CAMD researchers were successful in securing a range of research grants including an ARC Linkage grant (Prof Zetterlund/Dr Thickett with Nuplex Industries) and an ARC DECRA Fellowship (Dr Hongxu Lu, who is currently a postdoctoral fellow in CAMD). It was pleasing to see that CAMD tightened the links with industry as evidenced by research contracts with Baosteel (A/Prof Boyer) and Novogen (Prof Stenzel).
CAMD also hosted numerous visitors throughout the year, including several internationally renowned researchers who gave presentations as part of the CAMD lecture program. Strong international links are also reflected in a range of publications with collaborators from around the world. CAMD researchers were active in attending conferences and giving seminars, including a one day workshop entitled Polymer Nanoparticles, Self-Assembly and Colloids organized by CAMD researchers Zetterlund and Thickett at UNSW in November 2014.

Finally, we would like to say good-bye to Prof Andrew Lowe who took up the directorship position of the Nanochemistry Research Institute at Curtin University - we would like to congratulate him on his new position. Our Vice Chancellor Postdoctoral Fellow Dr Stuart Thickett was offered a position at the University of Tasmania. Dr Thickett has been with CAMD for three years and he was an invaluable member. We wish them both well in their future endeavours.

In closing, we would like to thank all the members of CAMD for their hard work, and we are also grateful for the ongoing support from the School of Chemical Engineering and the School of Chemistry.

Prof Martina Stenzel
Prof Per Zetterlund
Directors

Staff

Professor Martina Stenzel
Dr.rer.nat.(PhD) (1999)
Polymer Chemistry
University of Stuttgart, Germany

Martina Stenzel studied chemistry at the University of Bayreuth, Germany, before completing her PhD in 1999 at the Institute of Applied Macromolecular Chemistry, University of Stuttgart, Germany. She then moved to UNSW, Australia, as a postdoctoral fellow, sponsored by DAAD and was later employed as lecturer at UNSW. She is now a full Professor and Co-director of the Centre for Advanced Macromolecular Design (CAMD), a UNSW research Centre dedicated to the synthesis and application of polymers.

Her research interest is focused on the synthesis of functional polymers with complex architectures such as glycopolymers and other polymers for biomedical applications, especially polymers with in-built metal complexes for the delivery of metal-based anti-cancer drugs. The aim is to create nanoparticles for the treatment of cancer. One focal point is the formation of hybrid materials from biopolymers such as polysaccharides and proteins with synthetic polymers. Martina has published more than 200 peer reviewed papers, mainly on RAFT polymerization and biomedical applications. Martina currently serves on eight editorial advisory boards in the area of polymer science and biomaterials and is a scientific editor of RSC Materials Horizons.

She is a member of the ARC College of experts and a member of the national committee for chemistry of the Australian Academy of Science. Martina has received several awards for her work including the 2011 Le Fèvre Memorial Prize and the 2013 NSW Science and Engineering award - Excellence in Engineering.

Staff

Professor Per Zetterlund
PhD 1998
Polymer Chemistry
University of Leeds, UK

Per Zetterlund graduated from The Royal Institute of Technology in Stockholm (Sweden) in 1994, obtained his Ph.D. at Leeds University (UK) in 1998, and subsequently conducted postdoctoral research at Griffith University (Brisbane, Australia).

In 1999, he became Assistant Professor at Osaka City University (Japan) in the group of Prof. Yamada, and moved to Kobe University (Japan) in 2003 to join the team of Prof. Okubo, where he was promoted to Associate Prof in 2005. Since 2009, he is working at The Centre for Advanced Macromolecular Design (CAMD) at The University of New South Wales (Sydney, Australia), where he is currently full Professor and co-Director of the Centre.

Prof Zetterlund's research is concerned with the synthesis of polymer, polymeric nanoparticles, as well as hybrid polymeric materials with a variety of applications ranging from materials science to nanomedicine. Important aspects of his research include the use of environmentally friendly carbon dioxide in polymer (nanoparticle) synthesis, as well as experimental/theoretical studies of polymerization in nanoreactors. He has to date published ~150 peer-reviewed papers, and currently serves on the editorial boards of the journals Macromolecular Theory and Simulations and Polymer Chemistry.

Staff

Professor Andrew Lowe
DSc (2009) PhD (1997)
Polymer Chemistry
University of Sussex, UK

Andrew Lowe graduated from the University of Sussex with BSc (Hons) (1993), DPhil (1998), and DSc (2009) degrees, completing his DPhil under the supervision of Professors Steven P. Armes and Norman C. Billingham.

He spent approximately 10 years at the University of Southern Mississippi, in Hattiesburg, Mississippi, first as a postdoctoral researcher then as an Assistant Professor of Organic Chemistry and subsequently as an Associate Professor of Polymer Science & Engineering (with tenure).

He has published ca. 120 peer reviewed papers, book chapters, encyclopedia articles and patents. Professor Lowe's current research interests are focused on applications of RAFT, ROMP, and highly efficient thiol-based coupling chemistries as a means of preparing novel, stimulus responsive polymers. Prof. Lowe currently serves as an Associate Editor for Polymer International and is a member of the editorial advisory boards for a number of journals.

Staff

Associate Professor Cyrille Boyer
PhD (2006)
Polymer Chemistry
University of Montpellier II, France

Cyrille Boyer received his PhD in polymer chemistry from the University of Montpellier II in 2006. In 2010, he was appointed as a lecturer and he received an Australian Research Council Fellow (APD-ARC). In 2012, Cyrille was promoted Senior Lecturer at the School of Chemical Engineering and he was awarded an Australian Research Council Future Fellowship.

He received several awards, including the Scopus Young Researcher of the Year Award 2012, UNSW Research Excellence Award and was listed as finalist of NSW innovation award in 2014. In 2013, Cyrille was promoted to Associate Professor.

Cyrille has published over 135 research articles, 19 conference papers, 5 granted patents and 2 provisional patents, which have garnered over 5200 citations (his H-index is 43). Cyrille's research interests mainly cover the preparation of hybrid organic-inorganic nanoparticles for imaging & drug delivery and the use of photoinduced living polymerization (photopolymerization).

Cyrille serves on the editorial boards of Polymer Chemistry and European Polymer Journal.

Staff

Associate Professor Frank Lucien
PhD (1997)
Chemical Engineering, UNSW

Frank Lucien received his PhD in Chemical Engineering in 1997 from the University of New South Wales. His doctoral research was concerned with solubility enhancement of solids in supercritical CO_2.

He carried out postdoctoral research at F. Hoffmann-La Roche (Basel, Switzerland) and continued work on high pressure processes involving CO_2. He was appointed as a lecturer in the School of Chemical Engineering & Industrial Chemistry at UNSW in 1997.

His early work involved the use of CO_2-expanded liquids as reaction media, focusing on catalytic hydrogenation and catalytic chain transfer polymerization. He was promoted to A/Prof. in 2009 and is currently conducting research on radical polymerization in CO_2-induced emulsions for the synthesis of polymeric nanoparticles (with Prof. Per Zetterlund). He has published over 80 scientific papers, including 4 book chapters and 1 patent.

Staff

Dr Anthony Granville - Lecturer
PhD (2004)
Polymer Chemistry
University of Akron, USA

Anthony Granville graduated from Stevens Institute of Technology (New Jersey, USA) with a degree in chemistry before going on to the University of Akron (Ohio, USA) and completing his PhD in polymer chemistry.

Upon completing postdoctoral work in CAMD, he was appointed as an Academic Fellow to the School of Chemical Engineering at UNSW before being converted to a full-time lecturer at the school.

Tony's current research interests deals with the investigating novel synthetic molecules capable of undergoing the mussel-inspired self-polymerisation process as well as their applications to health, water purification, and energy. This work has led to investigations into the radiolabelling of nanocapsules of these materials (in the form of an AINSE grant at ANSTO), investigating their capabilities as osteoblast promoters, and new surface polymerisations from these constructs using UV irradiation.

Tony is secretary of the RACI NSW POLY group as well as on several academic boards at UNSW.

Staff

Dr Peter Roth - Research Fellow
PhD (2009)
Chemistry
University of Mainz, Germany

Peter Roth studied chemistry at the University of Mainz (Germany), the University of Massachusetts (USA), and Seoul National University (South Korea), obtaining his PhD in 2009 in the group of Patrick Theato (Mainz). His PhD work focused on the end group modification of RAFT-made (co)polymers using activated esters and functional thiosulfonates.

After obtaining a pre-diploma in Psychology in 2010 from the University of Mainz, he did postdoctoral research at the University of New South Wales, Sydney, working with Profs Tom Davis and Andrew Lowe on the self-assembly of homopolymers into vesicles from 2010–2012.

He received an ARC DECRA on the development of novel stimulus responsive polymers in 2012 and was promoted to Research Fellow in 2013.

His group's research focused on novel smart materials responding to (multiple) external stimuli such as temperature (including rare aqueous UCST systems), presence of specific chemical analytes, pH, and mechanical agitation; the use and development of efficient post-polymerization modification reactions; and the use of multicomponent reactions in the design and preparation of novel multifunctional materials.

Staff

Dr Stuart Thickett - Research Fellow
PhD (2008)
Chemistry
University of Sydney

Stuart Thickett received his BSc (Hons) from The University of Sydney in 2004 and completed his PhD with Professor Robert Gilbert at The University of Sydney in 2008.

He has since held post-doctoral positions at The University of Toronto, Canada (with Professor Mitchell Winnik) and The University of Sydney (with Associate Professor Chiara Neto).

In 2012 he was awarded a Vice-Chancellor's Post-Doctoral Fellowship to join the School of Chemical Engineering at UNSW. His work focuses on the physical chemistry of soft matter, specifically polymers, colloids, nanoparticles and thin films.

He is interested in the underlying kinetic and mechanistic phenomena that govern such systems, with the goal of using this knowledge to create new materials with specific properties and attributes.

Staff

Dr Pu Xiao - Research Fellow
PhD (2009)
Polymer Chemistry and Physics
Wuhan University, China

Dr. Pu Xiao obtained his Bachelor's degree (2004) in Chemistry and PhD (2009) in Polymer at Wuhan University (China).

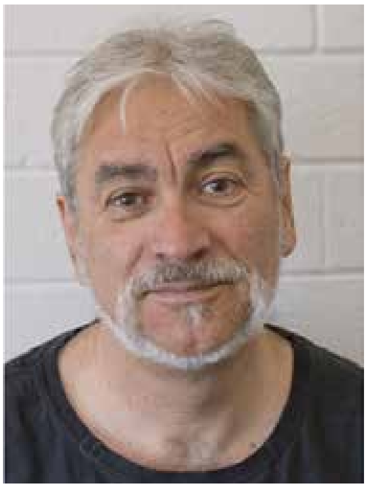
He started his academic career as a Scientific Associate at the University of Applied Sciences and Arts Northwestern Switzerland (FHNW, Switzerland) from 2009. In 2012, he moved to the Institute of Materials Science of Mulhouse (IS2M, CNRS, France) and worked as a Post-doctoral Fellow.

Since 2014, he has been working as a Research Fellow (ARC DECRA) in Prof Stenzel's group at CAMD at UNSW.

His research interests are focused on the fabrication of polymeric materials in a green environment such as mild visible light and nanomaterials for environmental or biomedical applications (e.g. nanodiamond/polymer hybrid nanomarials as drug delivery systems).

He has published >65 peer-reviewed papers, most of which are concerned with novel photoinitiating systems of polymerization.

Staff



Dr Istvan Jacenyik - Centre Manager
DPharm (2009)
Semmelweis University, Hungary

Eh Hau Pan - Technical Officer
BE - Industrial Chemistry (2006)
UNSW

Research Associates:

Dr Krzysztof Babiuch
Dr Aydan Dag
Dr Hien Duong
Dr Bunyamin Karagoz
Dr Hongxu Lu
Dr Wei Scarano
Dr Antoine Tardy
Dr Yiwen Pei
Dr Jiangtao Xu

Postgraduates:

Nik Nik Mohd Adnan
Sri Agustina
Hafiz Aziz
Rhiannon Batchelor
Kash Bhullar
Siti Hajjar Che Man
Teddy Chang
Fan Chen (Charles)
Yong Chen
Siming Dong (Sam)
Alice Du
Ka Wai Fan

Postgraduates cont.:

Noor Hadzuin Nik Hadzir (Awin)
Johannes Van Hensbergen
Fumi Ishizuka
Yanyan Jiang
Yan Jin (Joey)
Kenward Jung
Yee Yee Khine
Solomon Le-Masurier
Yang Li (Daniel)
Johnny Lim
Mingxia Lu (Mia)
Diep Nguyen
Thuy Khanh Nguyen
Shyam Sundar Malli Prakash
Jing Yang Quek
Narasinga Rao Hanumanth Rao
Wei Scarano
Sivaprakash Shanmugam
Yusuke Sugihara
Victoria Teo
Robert Utama
Chin Ken Wong (Ken)
Jonathan Yeow
Yujian Zhai
Jiacheng Zhao
Yicheng Zhu (Mike)

PhD Completions:

Bianca Blunden: Synthesis of drug delivery carriers for anti-metastatic ruthenium drugs (Prof Stenzel)

Wei Scarano: Mini-Trojan horses for the delivery of platinum drugs (Prof Stenzel)

Robert Utama: Inverse miniemulsion periphery RAFT polymerization: A facile pathway to polymeric nanocapsules (Profs Stenzel/Zetterlund)

Yusuke Sugihara: Kinetic/mechanistic aspects of radical polymerization: Homogeneous and heterogeneous systems (Prof Zetterlund)

Siti Hajjar Che man: Synthesis of hybrid polymer/graphene materials using miniemulsion polymerization (Prof Zetterlund/Dr Thickett)

Johan S. Basuki: Design of iron oxide nanoparticles for therapeutic applications (A/ Prof Boyer/Prof Davis)

Yang Li: Design of MRI contrast agents (A/ Prof Boyer/Prof Davis)

Solomon Le-Masurier: Polydopamine coatings yielding high density glycopolymer brushes for biomedical applications (Dr. Granville)

Visitors:

Alexia Brun
Cyril Chauveau
Daubree Clementine
Basile Commarieu
Ann-Katrin Friedrich
ChangKui Fu
Fanny Grange
Timo Hees
Maribel Hernandez
Miriam Koldevitz
Jonas Kolsch
Kim Oehlenschlaeger
Alberto Piloni
Masayoshi Tokuda
Marie Vermande
Sylvia
Maria Oeppling
Silvana Röse

Collaborators

UNSW
Prof Rose Amal (Chemical Engineering)
Prof Robert Burford (Chemical Engineering)
Dr Nicolas Barraud (BABS)
Dr Rita Henderson (Water Research)
Prof Naresh Kumar (Chemistry)
Dr Megan Lord (GSBmE)
Dr Penny Martens (GSBmE)
Prof David Morris (St George Hospital)
Dr Yun Hau Ng (Chemical Engineering)
Prof Laura Poole-Warren (GSBmE)
Dr Robert Taylor (Mech & Man Eng)
Dr Renee Whan (Biomedical Imaging)
Prof John Whitelock (GSBmE)
A/Prof Jia-Lin Yang (Prince of Wales)

Domestic
Prof Paul de Souza (Ingham Institute)
A/Prof Brian Hawkett (University of Sydney)
Dr Chiara Neto (University of Sydney)
Dr Margaret Sunde (University of Sydney)
Dr Kristopher Thurecht (UQ)

International
Dr Fawaz Aldabbagh (Ireland, Galway)
Prof Christopher Barner-Kowollik (KIT, Germany)
Prof Laurent Billon (Pau, France)
Prof B. Boutevin (Montpellier II, France)
Prof Jerome Claverie (Montréal, Canada)
Dr Ghislain David (Montpellier II, France)
Prof Filip Du Prez (Ghent, Belgium)
Prof Laurent Fontaine (Mans, France)
Prof David Haddleton (Warwick, UK)
A/Prof Atsushi Kajiwara (Nara Uni., Japan)
Dr Sophie Laurent (Mons, Belgium)
Prof H.-U. Moritz, (Hamburg, Germany)
Prof Rachel O'Reilly (Warwick, UK)
A/Prof Nicolay Tsarevsky (Sthn Methodist, USA)
Prof Philipp Vana (Göttingen, Germany)
Prof Tanja Weil (Ulm, Germany)
Prof Shigeru Yamago (Kyoto Japan)
Dr Guillaume Gody (Warwick, UK)
A/ Prof Hideto Minami (Kobe, Japan)
Prof Sebastien Perrier (Warwick, UK)
Dr Michael Gottschalt (Jena, Germany)
Prof Stephan Förster (Bayreuth, Germany)

Industrial
Henkel (Ireland)
Nubian Water Systems (Australia)
Nuplex Industries (Australia)
Otsuka Chemical Company (Otsuka, Japan)
Novogen (Australia)
Baosteel (China)

Polymer Synthesis

Polymer Synthesis

CAMD continues to make significant contributions in advanced polymer synthesis. Most efforts are centred on RAFT polymerization, a controlled/living radical polymerization technique investigated to great length at CAMD over the last decade. Current research aims both at improving the scope of RAFT as method and at exploiting its inherent advantages for state-of the art design of advanced macromolecules. Whereas conventional RAFT polymerization is sensitive to oxygen impurity and may not be controlled through external stimuli, a recent development of photoinduced RAFT polymerization eliminates these shortcomings while offering polymerization control over conjugated and unconjugated monomers. This method employs trace amounts of a photoredox catalyst which allows polymerizations to be reversibly stopped and continued by way of a visible light trigger. Taking advantage of the controlled nature of RAFT polymerization and its ability to produce well-defined A-B diblock copolymers, well-defined nanoparticles can be produced in onestep RAFT dispersion polymerisation. In this technique, a soluble macro-RAFT agent is used to polymerize a second monomer in a selective solvent that causes self-assembly of the growing second block giving access to distinct morphologies depending on recipe and reaction time. Recent research at CAMD has widened the scope of this technique, successfully applying it to a variety of functional monomers which has allowed, for example, a simple preparation of gold nanoparticle-functional microparticles.

Control over polymer microstructure is also being explored at the fundamental level using the combined approach of (i) biomimetic template radical polymerization and (ii) polymerization in nanoreactors in the form of submicron-sized micelles or droplets (Fig. 1). The realization that the concept of nanoreactors may be exploited in tandem with template polymerization has led to a biomimetic approach based on template polymerization involving nucleobase containing vinyl monomers in a segregated environment achieved via self-assembly of template diblock copolymers. This approach enables synthesis of polymer of very high molecular weight and extremely low dispersity. A further synthetic technique applied and progressed at CAMD is postpolymerization modification, the chemical transformation of reactive, pre-made (co)polymers. This method takes advantage of the high compatibility of the RAFT process with functional chemical groups. Using a variety of reactive precursors, we can introduce virtually any chemical functional group into a polymeric material, including groups that may not be compatible with the polymerization procedure. This gives access to a very wide range of functional materials with tuneable properties— see also Advanced Materials section.

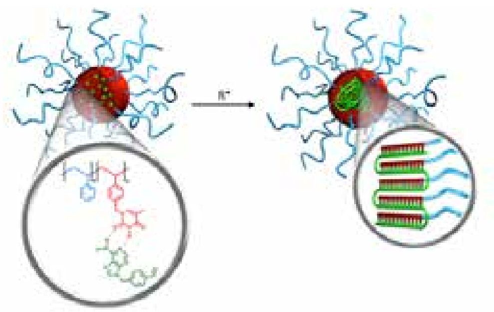
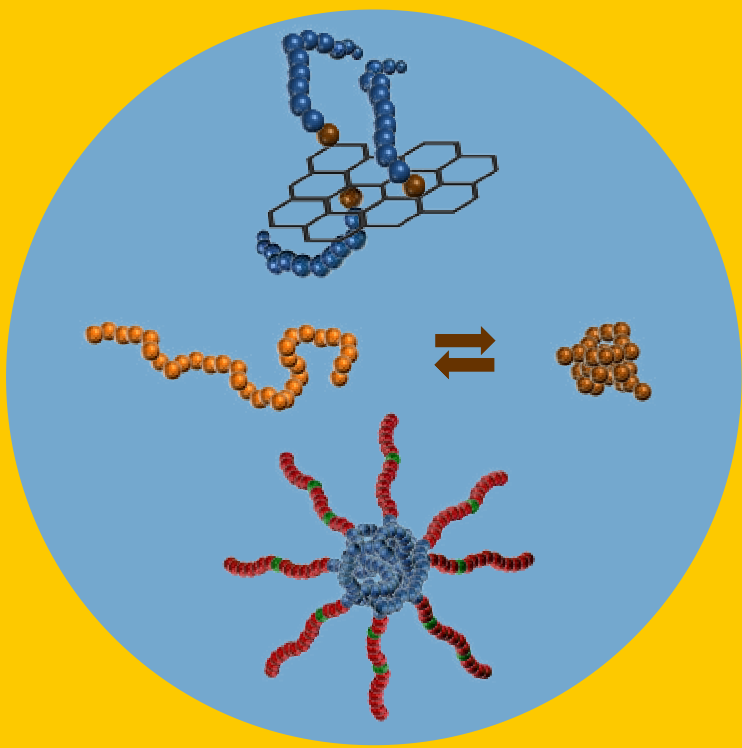


Fig. 1. Graphic illustration of template radical polymerization in nanoreactors (self-assembled micelles).

Advanced Materials



Advanced Materials

A number of projects deal with synthesis of advanced materials, e.g. stimulus responsive, "smart" polymers and nanocomposite materials. "Smart" polymers exhibit drastic changes of their physical properties in response to external stimuli such as temperature, light, certain gases, mechanical agitation, pH changes and specific chemical substances, and these materials offer great potential for applications in separation science, sensing and detection, and microfluidics. At CAMD, we aim to develop novel smart polymers, understand and improve their behaviour. Another area of research is surface modification of polymeric optical fibres for chemo- and biosensor technology, which involves generation of gold coated surfaces as a platform for various polymerisation and surface binding techniques.

The material graphene was discovered in 2004 (Noble Prize awarded in 2010) – it is the strongest material ever measured, and this is accompanied by a range of other extraordinary physical properties such as high thermal conductivity and high electrical conductivity. Graphene is seen as the material of the future, with the potential to revolutionize a wide range of industries from electronics to healthcare, and there is currently immense worldwide research activity in this area. At CAMD, we are interested in preparing novel polymeric nanocomposite materials with superior physical properties using graphene and graphene oxide.

The addition of graphene as a component of polymer nanocomposites results in superior material properties over the more common fillers such as carbon black. In order to fulfill the potential of such nanocomposites, a high degree of dispersion of graphene as individual two-dimensional sheets in the polymer matrix is essential. However, both pristine graphene and graphene oxide are incompatible with most hydrophobic polymers, and do not form homogeneous polymer composites. We specifically address these issues by employing various techniques involving (controlled/living) radical polymerization in aqueous dispersed systems for synthesis of polymer/graphene nanocomposite materials. The key in our approach is to exploit the amphiphilic properties of graphene oxide – it can behave as a surfactant in aqueous emulsions of oil (vinyl monomer) under suitable conditions. We thus conduct various types of dispersed phase polymerizations (emulsion, miniemulsion) using graphene oxide as surfactant, thereby accessing a novel route to graphene/polymer nanocomposite materials.

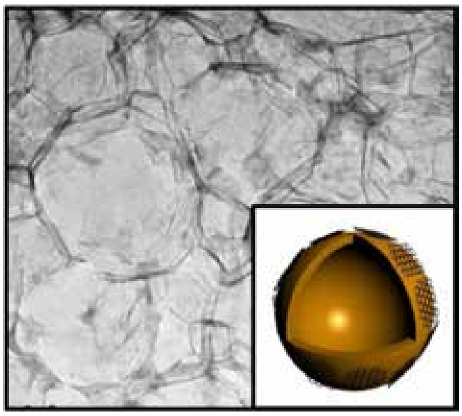


Fig. 2. TEM image and schematic illustration of hollow polymeric nanoparticle coated with graphene oxide nanosheets.

Energy/ Environment

Energy/ Environment

A number of active research themes are focused on energy/environment, including projects as diverse as development of environmentally friendly aqueous coatings, micropatterned surfaces or the efficient collection of water directly from the atmosphere, hybrid inorganic/organic nanomaterials for hydrogen storage, synthesis of various types of emulsions using carbon dioxide, and environmentally friendly synthesis of polybenzimidazoles for use in the in the energy storage and transfer realms.

Hydrogen could be the ultimate energy carrier enabling energy security and global sustainability in this 21st century. In the sun, hydrogen releases the energy that sustains life on Earth, while hydrogen bonded to carbon provides us with the so-called fossil fuels that have powered our industrial revolution. Unfortunately, a heavy reliance on finite resources and the adverse effects of fossil fuels on global climate are now threatening further development. In its purest form hydrogen has high energy content, and therefore hydrogen has naturally emerged as the only possible synthetic energy carrier with sufficient versatility to replace oil. However, the effective storage of hydrogen in a compact manner remains the central difficulty for its widespread use. Efforts over the last decades have targeted a range of materials capable of storing hydrogen with high density in the form of a hydride, e.g. MgH2, but the realization of successful strategies to control and balance competitive thermodynamics/kinetics requirements for the effective storage of hydrogen remains unanswered. The aim of this project is to develop a method for the facile production of MgH2 nanoparticles and their assembly into a tertiary structure providing remarkable stability to the magnesium nanoparticles against agglomeration and sintering.

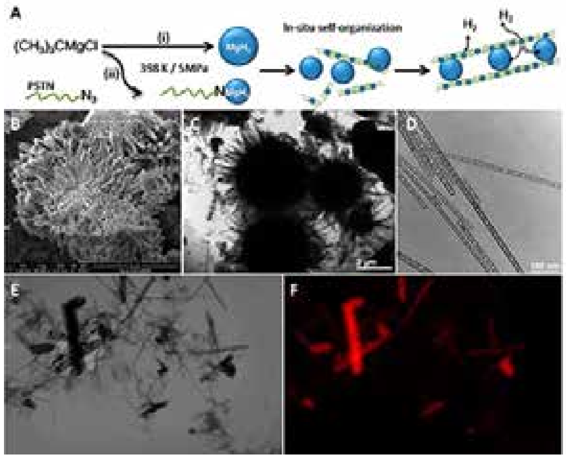


Fig. 3. Self-assembly of magnesium nanoparticles in polymer structures and SEM/TEM micrograph showing the self assembly in fibre structure

Mussels and other bivalves excrete a natural polymeric adhesive shown to be water insoluble, tough, and nontoxic. This material can be synthetically manufactured using dopamine as the monomeric material in a rather simple, weakly basic, aqueous solution. The dopamine compound will cyclise to form an indole intermediate before crosslinking to form the desired polymer. When a substrate is immersed in the aqueous solutions system, the polydopamine will form a homogeneous coating on the substrate surface. This paves the way for simple, benign coatings of a controlled thickness to be used for drug delivery, surface modification, and metal binding for electronic applications. The universality of this approach is being investigated with a focus on polybenzimidazoles, which are renowned for their high temperature properties as well as their ability to be used as proton exchange membranes when doped with acids.

Polymers for Health

Polymers for Health

The area of biomedical engineering has a strong need for new polymers to be able to finetune the interface between synthetic materials and the biological environment. RAFT (reversible addition-fragmentation chain transfer) polymerization is an excellent tool to address this need.

Polymers can be synthesized to suit different applications and CAMD researchers are active in the area of synthesis of nanoparticles for drug delivery to grafting of polymers from various surfaces to adjust their biocompatibility. In particular the area of drug delivery and imaging of nanoparticles is one of the main themes at CAMD. Self-assembled aggregates such as micelles, rod-like micelles and vesicles are proposed as drug carriers due to their hydrophobic interior, while size and shape is easily controlled by the underlying polymer. The nature of the block copolymer can be adjusted to solve a range of drug delivery problems. This includes traditional anti-cancer drugs, but also other, more challenging bioactive molecules such as DNA, heparin, peptides and metal-based drugs. The central questions are how can we design suitable polymers to encapsulate the drug and how does the polymer affect the properties of the nanoparticle?

Next to self-assembled block copolymers CAMD researchers are focussing on coating of inorganic nanoparticles such as gold nanoparticles or nanodiamonds to generate drug carriers that have added features such as they can be imaged or they can be used in hypothermia. On the quest for suitable drug delivery carriers for various drugs we developed a synthetic tool kit to achieve the best possible cellular uptake. We are interested in stabilizing the micelles by crosslinking, which often leads to better cell uptake. In addition, by replacing the more tradition PEG shell of micelles by other polymers such as polymers with a zwitterionic structure, we can create drug carriers that are not only nontoxic, but also show very high uptake efficiency.

CAMD researchers are inspired by Nature's building blocks such as sugars, proteins and polysaccharides. Synthetic routes are developed to create drug carriers that combine the tailored properties of synthetic polymers with the bioactivity of natural products. Drug carriers coated with albumin or sugars show high bioactivity, while at the same time the synthesis of these carriers can be very simple.

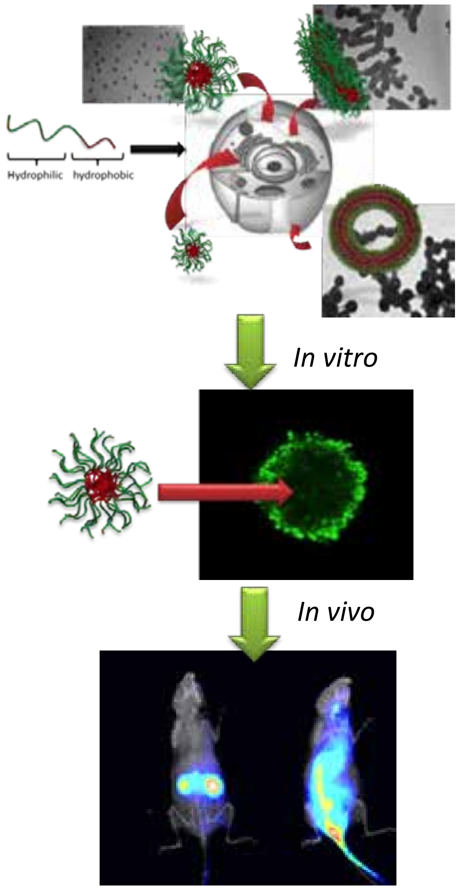


Fig. 4. Preparation of self-assembled core-shell nanoparticles for the delivery of drugs into cancer cells, and the subsequent study of the movement of these nanoparticles in multicellular cancer models and in vivo.

Research Grants 2014

▪ Development of a drug delivery system; Industrial research contract with Novogen; CI: Stenzel; 130k.

▪ Polymer Nanoparticles with Gradient Morphology for Environmentally Friendly Aqueous Coatings Applications; ARC Linkage; CI: Zetterlund, Thickett, Brinkhuis; $530k.

▪ Cellular responses to nanoparticles from cells on micropatterned surfaces; ARC DECRA; CI: Hongxu (Stenzel supervisor); $345k.

▪ Drug delivery of HPMA-based micelles in breast tumour histoids mimicking tumour classification; UNSW (Science) Early Career Research Grant; CI: Hongxu (Stenzel supervisor); $11.7k.

▪ Non-thermal plasma technology and optical diagnostics to facilitate research in food processing, water treatment, cell apoptosis, nanotechnology and polymerization; Major Research Equipment and Infrastructure Initiative (MREII) UNSW internal grant; CI: Led by PJ Cullen, involving Lucien/Granville; $123k.

▪ Hollow graphene-polymer nano capsules for catalytic applications; UNSW Engineering Faculty Research Grant; CI: Thickett (Zetterlund supervisor); $20k.

▪ Investigation of degradation products and potential contaminants to soil and groundwater, as well as the possible separation techniques, for microplastics in municipal waste organics; EPA (Environmental Protection Authority); CI: Granville (with USyd); $21k.

▪ Investigating the radioisotope binding and retention capability of new mussel-inspired polymers; AINSE Research Grant; Granville; $12.5k.

▪ Investigating the radioisotope and heavy metal binding capabilities of new mussel-inspired polymers; ANSTO LifeSciences Grant; Granville; $14k.

▪ Lithium Batteries; Industrial research contract with Baosteel; CI: Boyer with Wang/Aguey (UNSW) and UQ; $200k

Publications in 2014

1) Combining Ring-Opening Metathesis Polymerisation and Thiol-ene Coupling Chemistries: Facile Access to Novel Functional Linear and Non-linear Macromolecules
Macromolecular Rapid Communications (2014) 35, 391-404
[Invited contribution to special issue]
A. B. Lowe, M. Liu, J. A. van Hensbergen, R. P. Burford

2) Polymerization-Induced Self-Assembly: Ethanolic RAFT Dispersion Polymerization of 2-Phenylethyl Methacrylate
Polymer Chemistry (2014) 5, 2342–2351
Y. Pei, A. B. Lowe

3) The Precise Molecular Location of Gadolinium Atoms has a Significant Influence on the Efficacy of Nanoparticulate MRI Positive Contrast Agents
Polymer Chemistry (2014) 5, 2592–2601
Y. Li, S. Laurent, L. Esser, L. Vander Elst, R. N. Muller, A. B. Lowe, C. Boyer, T. P. Davis

4) Radio-opaque micelles for X-ray imaging
Aust. J. Chem. (2014) 67, 78–84 [Special issue for the Sino-Australian Polymer Workshop]
Z. Wang, T. Chang, L. Hunter, A. M. Gregory, M. H. Stenzel

5) Disulfide bridge based conjugation of peptides to RAFT polymers
Polymer Chemistry (2014) 5, 1772–1781
L. McDowall, M. H. Stenzel

6) Incorporation of 5-Hydroxyindazole into the Self-Polymerization of Dopamine for Novel Polymer Synthesis
Macromolecular Rapid Communication (2014) 35, 291-297
M. B. Peterson, S. P. Le-Masurier, K. Lim, J. M. Hook, P. Martens, A. M. Granville

7) Novel α,α-Bischolesteryl Functional (Co)Polymers: RAFT Radical Polymerization Synthesis and Preliminary Solution Characterization
Macromolecular Rapid Communications (2014) 35, 813-820
P. J. Roth, T. P. Davis, A. B. Lowe

8) Simultaneous Polymerization-Induced Self-Assembly (PISA) and Guest Molecule Encapsulation
Macromol. Rapid Commun. (2014) 35, 417-421
B. Karagoz , C. Boyer , T. P. Davis

9) Book Chapter: Recent developments in the design of nanomaterials for photothermal and magnetic hyperthermia induced controllable drug delivery
Nanoscience: Volume 2, (2014) 2, 225-254
A. E. Dunn, D. J. Dunn, M. Lim, C. Boyer, N. T. K. Thanh

10) Synthesis of polymeric nanomaterials for medicine (Editorial)
Polym. Chem. (2014) 5, 1501-1502
C. Boyer, T. P. Davis

11) A block copolymer-stabilized co-precipitation approach to magnetic iron oxide nanoparticles for potential use as MRI contrast agents
Polym. Chem. (2014) 5, 2611-2620
J. S. Basuki, A. Jacquemin, L. Esser, Y. Li, C. Boyer, T. P. Davis

12) Magnetic nanoparticles with diblock glycopolymer shells give lectin concentration-dependent MRI signals and selective cell uptake
Chem. Sci. (2014) 5, 715-726
J. S. Basuki, L. Esser, H. T. T. Duong, Q. Zhang, P. Wilson, M. R. Whittaker, D. M. Haddleton, C. Boyer, T. P. Davis

13) Spatial and temporal control of drug release through pH and alternating magnetic field induced breakage of Schiff base bonds
Polym. Chem. (2014) 5, 3311
A. E. Dunn, D. J. Dunn, A. Macmillan, R. Whan, T. Stait-Gardner, W. S. Price, M. Lim, C. Boyer

14) Photoredox catalyst-mediated atom transfer radical addition for polymer functionalization under visible light
Polym. Chem. (2014) 5, 3321
J. Xu, A. Atme, A. F. Marques Martins, K. Jung, C. Boyer

15) A Robust and Versatile Photoinduced Living Polymerization of Conjugated and Unconjugated Monomers and Its Oxygen Tolerance
J. Am. Chem. Soc. (2014) 136, 5508-5519
J. Xu, K. Jung, A. Atme, S. Shanmugam, C. Boyer

16) Organic Nitrate Functional Nanoparticles for the Glutathione-Triggered Slow-Release of Nitric Oxide
J. Polym. Sci.; Part A: Polym. Chem. (2014) online
DOI: 10.1002/pola.27221
H. T. T. Duong, A. Ho, T. P. Davis, C. Boyer

17) Thiol-Michael Coupling and ROMP: Facile Access to Functional exo-7-Oxanorbornene Dendron Macromonomers
Polymer International (2014) 63, 1174–1183
M. Liu, R. P. Burford, A. B. Lowe

Publications in 2014

18) Sequence-Controlled Multiblock Copolymers via RAFT Polymerization: Modelling and Simulations
Macromol. Theory Simul. (2014) 23, 331–339
P. B. Zetterlund, G. Gody, S. Perrier

19) Pushing the Limit of the RAFT Process: One-pot Synthesis of High-order Multiblock Copolymers of High Livingness at Full Monomer Conversion
Macromolecules (2014) 47, 3451-3460
G. Gody, T. Maschmeyer, P. B. Zetterlund, S. Perrier

20) One-pot polymer brush synthesis via simultaneous isocyanate coupling chemistry and "grafting from" RAFT polymerization
Polym. Chem. (2014) 5, 2816
S. P. Le-Masurier, G. Gody, S. Perrier, A. M. Granville

21) Hollow Hybrid Polymer-Graphene Oxide Nanoparticles via Pickering Miniemulsion Polymerization
Nanoscale (2014) 6, 8590
S. C. Thickett, N. Wood, Y-H. Ng, P. B. Zetterlund

22) Photoinduced Electron Transfer-Reversible Addition-Fragmentation Chain Transfer (PET-RAFT) Polymerization of Vinyl Acetate and Vinylpyrrolidinone: Kinetic and Oxygen Tolerance Study
Macromolecules (2014) DOI: 10.1021/ma500842u
S. Shanmugam, J. Xu, C. Boyer

23)Thiol-ene "click" reactions and recent applications in polymer and materials synthesis: A first update
Polymer Chemistry (2014) 5, 4820–4870
A. B. Lowe

24) Nano-sized graphene oxide as sole surfactant in miniemulsion polymerization for nanocomposite synthesis: Effect of pH and ionic strength
Polymer (2014) 55, 3490 - 3497
S. H. Che Man, D. Ly, M. R. Whittaker, S. C. Thickett, P. B. Zetterlund

25) RAFT Dispersion Polymerization of 3-Phenylpropyl Methacrylate with Poly[2-(dimethylamino)ethyl methacrylate] Macro-CTAs in Ethanol and Associated Thermoreversible Polymorphism
Soft Matter (2014) 10, 5787
Y. Pei, N. C. Dharsana, J. A. van Hensbergen, R. P. Burford, P. J. Roth, A. B. Lowe

26) Mechano-Responsive Polymer Solutions Based on CO2 Supersaturation: Shaking-induced Phase Transitions and Self-Assembly or Dissociation of Polymeric Nanoparticles
Chem. Commun. (2014) 50, 9561--9564
P. J. Roth, J. Y. Quek, Y. Zhu, B. M. Blunden, A. B. Lowe

27) Postpolymerization Synthesis of (Bis)Amide (Co)Polymers: Thermoresponsive Behavior and Self-association
Polymer (2014) 55, 4425-4431
Y. Zhu, A. B. Lowe, P. J. Roth

28) Synthesis of Fluorinated Alkoxyamines and Alkoxyamine-initiated Nitroxide-mediated Precipitation Polymerizations of Styrene in Supercritical Carbon Dioxide
Polym. Chem. (2014) 5, 5725–5733
C. Magee, A. Earla, J. Petraitis, C. Higa, R. Braslau, P. B. Zetterlund, F. Aldabbagh

29) Synthesis of pH-Responsive Nanocapsules via Inverse Miniemulsion Periphery RAFT Polymerization and Post-Polymerization Reaction
ACS Macro Letters (2014) 3, 935-939
R. H. Utama, M. Drechsler, S. Förster, P. B. Zetterlund, M. H. Stenzel

30) Protein Micro-Patterns by PEG Grafting on Dewetted PLGA Films
Langmuir (2014) 30 (39), pp 11714–11722
M. Ghezzi, S.C. Thickett, A.M. Telford, C.D. Easton, L. Meagher, C. Neto

31) Optimisation of the RAFT Polymerization Conditions for the in situ Formation of Nano-Objects via Dispersion Polymerization in Alcoholic Medium
Polymer Chemistry (2014) 5, 6990–7003
W. Zhao, G. Gody, S. Dong, P. B. Zetterlund, S. Perrier

32) Exploitation of the degenerative transfer mechanism in RAFT polymerization for synthesis of polymer of high livingness at full monomer conversion
Macromolecules (2014) 47, 639-649
G. Gody, T. Maschmeyer, P. B. Zetterlund, S. Perrier

33) Chain transfer to solvent in the radical polymerization of structurally diverse acrylamide monomers using straight-chain and branched alcohols as solvents
Polymer Chemistry (2014) 47, 639-649
C. Magee, Y. Sugihara, P. B. Zetterlund, F. Aldabbagh

Publications in 2014

34) Hydrophobically Modified Sulfobetaine Copolymers with Tunable Aqueous UCST Through Post-polymerization Modification of Poly(pentafluorophenyl acrylate)
Macromolecules (2014) 47, 750-762
P. A. Woodfield, Y. Zhu, Y. Pei, P. J. Roth

35) Composing Well-defined Stimulus-Responsive Materials through Postpolymerization Modification Reactions
Macromol. Chem. Phys. (2014) 215, 825-838
[invited review]
P. J. Roth

36) Superior Chemotherapeutic benefits from the ruthenium-based anti-metastatic drug NAMI-A through conjugation to polymeric micelles
Macromolecules (2014) 47, 1646-1655
B. M. Blunden, A. Rawal, H. Lu, M. H. Stenzel

37)Size effects of self-assembled block copolymers spherical micelles and vesicle on cellular uptake in human colon carcinoma cells
J. Mater. Chem B (2014) 2, 2883–2891
T. Chang, M. S. Lord, B. Bergmann, A. McMillan, M. H. Stenzel

38) Polymers with platinum drugs and other macromolecular metal complexes for cancer treatment
Progress in Polymer Science (2014) 39 1614–1643
M. Callari, J. Aldrich-Wright, P. L. de Souza, M. H Stenzel

39) Drug carriers for the delivery of therapeutic peptides
Biomacromolecules (2014) 15, 1097-1114
A. Du, M. H. Stenzel

40) Control of glycopolymer nanoparticle morphology by a one-pot, double modification procedure using thiolactones
Macromolecular Rapid Commun (2014) 35, 1128-1134
Y. Chen, P. Espeel, S. Reinicke, F. E. Du Prez, M. H. Stenzel

41) Albumin-Micelles via a one-pot Technology Platform for the Delivery of Drugs
Chem Comm (2014) 50, 6394--6397
Y. Jiang, M. Liang, D. Svejkar, G. Hart-Smith, H. Lu, W. Scarano, M. H. Stenzel

42) Boronic acid ester with dopamine as a tool for bioconjugation and for visualization of cell apoptosis
Chem Comm (2014) 50, 6390--6393
W. Scarano, H. Lu, M. H. Stenzel

43) Synthesis of Complex Macromolecules Using Iterative Copper(0)-Mediated Radical Polymerization
J. Polym. Sci.; Part A: Polym. Chem. (2014) 52, 2083–2098 [invited Highlight Article]
C. Boyer, P. B. Zetterlund, M. R. Whittaker

44) ROMP (Co)Polymers with Pendent Alkyne Groups: Post-polymerization Modification Employing Highly Efficient Thiol-yne and CuAAC Coupling Chemistries
Polymer Chemistry (2014) 5, 5339–5349
J. A. van Hensbergen, R. P. Burford, A. B. Lowe

45)Macroporous Uniform Azide- and Alkyne-functional Polymer Microspheres with Tuneable Surface Area: Synthesis, In-depth Characterization and Click-Modification
Polymer Chemistry (2014) 5, 5689–5699
M. Albuszis, P. J. Roth, W. Pauer, H.-U. Moritz

46) Aqueous photoinduced living/controlled polymerization: tailoring for bioconjugation
Chem. Sci. (2014) 5, 3568–3575
J. Xu, K. Jung, N. A. Corrigan, C. Boyer

47) Functional gold nanoparticles for the storage and controlled release of nitric oxide: applications in biofilm dispersal and intracellular delivery
J. Mater. Chem. B (2014) 2, 5003–5011
H. T. T. Duong, N. N. M. Adnan, N. Barraud, J. S. Basuki, S. K. Kutty, K. Jung, N. Kumar, T. P. Davis, C. Boyer

48)Oxygen Tolerance Study of Photoinduced Electron Transfer–Reversible Addition–Fragmentation Chain Transfer (PET-RAFT) Polymerization Mediated by Ru(bpy)3Cl2
Macromolecules (2014) 47, 4217-4229
J. Xu, K. Jung, C. Boyer

49) Combining Enzymatic Monomer Transformation with Photoinduced Electron Transfer - Reversible Addition-Fragmentation Chain Transfer for the Synthesis of Complex Multiblock Copolymers
ACS Macro Letters (2014) 3, 633-638
C. Fu, J. Xu, L. Tao, C. Boyer

50) In Situ Formation of Polymer-Gold Composite Nanoparticles with Tunable Morphologies Quick View Full Text
ACS Macro Letters (2014) 3, 591-596
R. Bleach, B. Karagoz, S. M. Prakash, T. P. Davis, C. Boyer

Publications in 2014

51)Nanoparticle (Star Polymer) Delivery of Nitric Oxide Effectively Negates Pseudomonas aeruginosa Biofilm Formation
Biomacromolecules (2014) 15, 2583-2589
H. T. T. Duong, K. Jung, S. K. Kutty, S.Agustina, N. N. M. Adnan, J. S. Basuki, N. Kumar, T. P. Davis, N. Barraud, C. Boyer

52) Biomimetic Polymers Responsive to a Biological Signaling Molecule: Nitric Oxide Triggered Reversible Self-assembly of Single Macromolecular Chains into Nanoparticles
Angewandte Chemie, International Edition (2014) 53, 7779 –7784
J. Hu, M. R. Whittaker, H. Duong, Y. Li, C. Boyer, T. P. Davis

53) Nanoparticles Based on Star Polymers as Theranostic Vectors: Endosomal-Triggered Drug Release Combined with MRI Sensitivity
Advanced Healthcare Materials (2014) DOI: 10.1002/adhm.201400164
Y. Li, H. T. T. Duong, S. Laurent, A. MacMillan, R. M. Whan, L. Vander Elst, R. N. Muller, J. Hu, A. Lowe, C. Boyer, T. P. Davis

54) Functional α,ω-Dienes via Thiol-Michael Coupling Chemistry: Synthesis, Oxidative Protection, Acyclic Diene Metathesis (ADMET) Polymerization and Radical Thiol-ene Modification
Polymer Chemistry (2014) 5, 6225–6235
J. A. van Hensbergen, T. W. Gaines, K. B. Wagener, R. P. Burford, A. B. Lowe

55) Cu(0)-Mediated Controlled/Living Radical Polymerization: A Tool for Precise Multiblock Copolymer Synthesis
ACS Books: "Sequence-Controlled Polymers: Synthesis, Self-Assembly, and Properties"
doi: 10.1021/bk-2014-1170.ch013
C. Boyer, M. Whittaker, P. Zetterlund

56) Thiol-yne 'Click'/Coupling Chemistry and Recent Applications in Polymer and Materials Synthesis and Modification
Invited contribution for a special issue of Polymer (2014) 55 5517-5549
A. B. Lowe

57) An Efficient and Highly Versatile Synthetic Route to Prepare Iron Oxide Nanoparticles/Nanocomposites with Tunable Morphologies
Langmuir (2014) 30, 10493-10502
B. Karagoz, J. Yeow, L. Esser, S. M. Prakash, R. P. Kuchel, T. P. Davis, C. Boyer

58) Switching the thermodynamics of MgH2 nanoparticles through polystyrene stabilisation and oxidation
RSC Adv. (2014) 4, 39934–39940
E. Setijadi, C. Boyer, K-F. Aguey-Zinsou

59) Synthesis and Application of Glycopolymers
Chapter in Encyclopedia Of Polymer Science and Technology (2014), pages 1-58
K. Babiuch, M. H. Stenzel

60) Successful miniemulsion ATRP using an anionic surfactant: Minimization of deactivator loss by addition of a halide salt
Macromolecules (2014) 47, 6230-6237
V. L. Teo, B. J. Davis, N. V. Tsarevsky, P. B. Zetterlund

61) Albendazole loaded albumin nanoparticles for ovarian cancer therapy
European Journal of Nanomedicine (2014), 6, 227.
L. Noorani, H. Pourgholami Mohammad, M. Liang, L. Morris David, M. Stenzel

62) Introducing drug delivery vehicle in albendazole decreases tumor burden, reduses VEGF and inhibits ascites in ovarian cancer xenograft model
Asia Pacific Journal of Clinical Oncology (2014), 10, 45-50.
L. Noorani, M. Pourgholami, M. Stenzel, D. Morris

63) Polyion Complex Micelle Based on Albumin-Polymer Conjugates: Multifunctional Oligonucleotide Transfection Vectors for Anticancer Chemotherapeutics
Biomacromolecules (2014), 15, 4195-4205.
Y. Jiang, H. Lu, Y. Y. Khine, A. Dag, M. H. Stenzel

64) Drug Conjugation to Cyclic Peptide-Polymer Self-Assembling Nanotubes
Chemistry European Journal (2014), 20, 12745-12749.
B. M. Blunden, R. Chapman, M. Danial, H. Lu, K. A. Jolliffe, S. Perrier, M. H. Stenzel

65) Enhanced drug toxicity by conjugation of platinum drugs to polymers with guanidine containing zwitterionic functional groups that mimic cell-penetrating peptides
Polymer Chemistry (2014), 5, 6600-6610.
K. J. Abd Karim, R. H. Utama, H. Lu, M. H. Stenzel,

66) Fructose-coated nanoparticles: a promising drug nanocarrier for triple-negative breast cancer therapy
Chem Comm (2014), 50, 15928-15931.
J. Zhao, K. Babiuch, H. Lu, A. Dag, M. Gottschaldt, M. H. Stenzel

Highlights Awards & Other Activities

CAMD seminar series:

Prof Andreas Fery
(Bayreuth University, Germany)

Prof Chao Gao
(Zhejiang University, China)

Prof Kathryn Uhrich
(Rutgers University), US)

Dr Jatin Kumar
(A* star, Singapore)

Dr Yukiya Kitayama
(Kobe University, Japan)

High impact papers:

- A Robust and Versatile Photoinduced Living Polymerization of Conjugated and Unconjugated Monomers and Its Oxygen Tolerance, J. Xu, K. Jung, A. Atme, S. Shammugam, C. Boyer, J. Am. Chem. Soc., 2014, 136, 5508.

- Aqueous Photoinduced Living/Controlled Polymerization: Tailoring for Bioconjugation, J. Xu, K. Jung, N. A. Corrigan, C. Boyer, Chem. Sci. 2014, 5, 3568-3575.

- Hollow Hybrid Polymer-Graphene Oxide Nanoparticles via Pickering Miniemulsion Polymerization, S. C. Thickett, N. Wood, Y. H. Ng, P. B. Zetterlund, Nanoscale, 2014, 6, 8590-8594.

Recognition:

- Martina Stenzel's research highlighted in Chemical Communications "Interview with…." (only two Australians so far)

- Feature article on the ARC website "Hunting cancer with nanotechnology"

Service:

- Martina Stenzel joined National Chemistry Committee of the Australian Academy of Science

- Per Zetterlund served as Expert Witness in case involving Nuplex Industries

- Stuart Thickett and Per Zetterlund organized RACI NSW Polymer Workshop at UNSW in Nov. 14, entitled Polymer Nanoparticles, Self-Assembly and Colloids.

Editorial and publications:

- Martina Stenzel appointed as Scientific editor for RSC journal Materials Horizon

- Martina Stenzel joined the editorial advisory board of Acta Biomaterialia and Journal of Materials Chemistry B

Highlights Awards & Other Activities

Invited keynote presentations:

▪"Enhanced the cellular uptake of nanoparticles by attaching bioactive groups"
Invited lecture by M. Stenzel at Functional Polymeric Materials, 10th – 13th Feb 2014, Cancun, Mexico

▪ "Design of functional micelles for enhanced cellular uptake"
Invited lecture by M. Stenzel at China-Australia Workshop, 30th of April – 2nd May 2014, Melbourne

▪ "Design of functional micelles for enhanced cellular uptake and their movement in cancer spheroids"
Invited lecture by M. Stenzel at NIMS (National Institute for Materials Science) conference, 1st July- 3rd July, Tsukuba, Japan

▪ "Design of functional micelles for enhanced cellular uptake and their movement in cancer spheroids"
Invited lecture by M. Stenzel at the MACRO 2014, 6th – 11th July 2014, Chiangmai, Thailand

▪ "Enhanced the cellular uptake of nanoparticles by attaching bioactive groups"
Presentation by M. Stenzel at the ACS (American Chemical Society) meeting, 10th -14th August 2014, San Francisco, US

▪ "Self-assembled glycopolymers"
Invited lecture by M. Stenzel at the ACS (American Chemical Society) meeting, 10th -14th August 2014, San Francisco, US

▪ "Macromolecular Ruthenium Complexes as Anticancer Agents"
Invited lecture by M. Stenzel at the ACS (American Chemical Society) meeting, 10th -14th August 2014, San Francisco, US

▪ "Design of functional micelles for enhanced cellular uptake and their movement in cancer spheroids"
Invited lecture by M. Stenzel at the XIII Meeting of the polymer group of the Spanish Royal Chemistry and Royal Physics Societies, 7th – 10th September 2014, Girona, Spain

▪"Photoelectron transfer – reversible addition fragmentation chain transfer (PET-RAFT)"
Invited lecture by C. Boyer at the ACS (American Chemical Society) meeting, 10th -14th August 2014, San Francisco, US

▪"Photoactivated polymerization", invited lecture by C. Boyer at the Living Radical Polymerization Symposium (Turkey), 5-10th May 2014

▪"Expanding the Polydopamine Self-Polymerisation System to New Quinone Structures for the Synthesis of "Green" Polymer Coatings"
Invited lecture by A. Granville at the NanoBio Australia Conference meeting, 6th-10th July 2014, Brisbane AU

Seminars by CAMD researchers:

▪ M. Stenzel at Karlsruhe Institute of Technology, Germany (Dec 2014)

▪ M. Stenzel at LaTrobe University (May 2014)

▪ A. Granville at University of Western Sydney (October 2014)

Statement of Financial Performance
For the Year Ended 2014

	Note	2014 $000	2013 $000	Difference $000	Difference %
REVENUE					
Ext. Research - ARC		1,096	1,326	(229)	-17%
Ext. Research - NHMRC				-	
Ext. Research - Other		130	28	103	373%
Research Revenue:	1	1,227	1,353	(127)	-9%
Sub-total of Fundraising drawdowns - from ORSORIN		-	-	-	
Donations & Bequest - Div'n Advancement		-	-	-	
Donations & Bequest - Draw downs		-	-	-	
Strategic Funds		318	136	182	133%
Major Research Equipment		106	-	106	
Research Matching funds				-	
EB Gaps				-	
UNSW Contributions		424	136	288	211%
Faculty Contributions	2	40	38	2	5%
Other Research Revenues	3	26	-	26	
Commercial Activity - Fees for Service		-	5	(5)	-100%
Sundry Other Revenue		(0)	0	(0)	-100%
Total Revenue		1,717	1,533	157	12%
COST					
Total Academic		926	1,055	(129)	-12%
Total General		173	103	70	68%
Salaries, Oncosts and other staff costs		1,100	1,160	(60)	-5%
Scholarship Stipends		149	174	(25)	-15%
Contract & Consulting Services		0	0	(0)	-52%
Repairs and Maintenance		2	10	(8)	-79%
Consumables		120	101	19	19%
Travel		110	105	5	5%
Equipment Non Capitalised		9	7	2	26%
Entertainment		1	1	(0)	-41%
Marketing		-	-	-	
Miscellaneous Expenses		132	83	49	59%
Total Cost		1,623	1,642	(18)	-1%
TOTAL CONTRIBUTION - SURPLUS/(DEFICIT)		93	(109)	176	-186%
Depreciation		12	15	(2)	-17%
SURPLUS/(DEFICIT) after DEPRECIATION		$ 81	$ (123)	178	-166%
Cashflow Funded Capital Expenditure (CAPEX)		100	-	100	

NOTES:

	2014 $000	2013 $000	Difference $000	Difference %
1. Revenue in Advance noted in Creditors & Other Liabilities.				
Research Revenue generated (cash basis).	$ 1,256	1,334	(78)	-6%
Category 1 Research Revenue therein	1,096	1,326		
2. UNSW Budget model includes other revenue items				
Teaching Revenue			-	
Block Grants	-	-	-	
Indirect Cost Recoveries	-	-	-	
3. Other Research Revenue includes internal fund transfers.				
4. Restricted Funds - Cash at year end	$ 424	$ 402	22	
5. Funds available in Division of Advancement				

Statement of Financial Position
As at December 2014

	Note	2014 $000	2013 $000
UNSW Australia Internal Cash	6	240	228
Accounts Receivable	7	0	1
Sundry Assets		16	(0)
Investments		-	-
Property Plant & Equipment	8	122	35
Creditors and Other Liabilities	1	45	6
NET ASSETS		$ 333	$ 257

NOTES:

6. Statements are prepared on UNSW Accounting principles - Operating and Strategic funds adjusted revenue.

7. UNSW has central provisions in respect of payments made to employees and taxation.
Such provisions will not be reflected in this Centre's Statement of Financial Position.

8. Cash balance includes the GST centralised daily on Debtor and Creditor balances.

9. Accounts Receivable are gross value - inclusive of applicable GST.

10. Property Plant & Equipment is depreciated over the expected useful life of the asset.

11. UNSW Division of Advancement holds donated funds centrally.
Draw down of funds to the Centre is reflected in the Statement of Financial Performance.