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From Fundamentals to Applications: Living Polymer Science at the 29th Australasian Polymer Symposium

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The previous 28th Australasian Polymer Symposium in Rotorua, New Zealand, was particularly notable for its elegant fusion of polymer science with biomaterials. As co-Chairs Greg Russell and Martina Stenzel put it in their foreword[1] to the corresponding special issue of the *Australian Journal of Chemistry*: 'We must embrace the important challenges posed by the frontier between polymers and biomaterials, for the better future of the world depends on it.' Although this notion was retained in the conference program of the recent 29th Australasian Polymer Symposium (APS) held in Hobart in February this year, it is notable that the current research and funding culture is permeated with a strong application focus on the biomaterials/synthetic polymer frontier and the need (or pressure?) to generate immediate- and short-term benefits for society. This is also evidenced by an inflation of 'nano/bio' buzz words in the titles of journal articles as well as funding applications. While an application focus is highly important, great care has to be taken that more fundamental questions also continue to be addressed: after all, the fusion of biological with synthetic polymer science can only advance and benefit immediate applications when the underpinning polymerization processes are fully understood. It is an often overlooked fact that access to the kinetics and mechanism of a polymerization process are key to predicting and controlling polymer microstructures and functionality as well as the design of improved polymerization protocols for accessing well-defined and complex polymer structures. Thus, the main message, which is evident in the current resulting special issue, is that applications and fundamental investigations must support each other.

The application-driven fusion of biological aims with synthetic polymer science is highlighted in the current special issue by several articles: a review on the design of star polymer systems and their application in drug delivery[2] contributed by Greg Qiao and James Wiltshire (one of the 29th APS Treloar Prize[3] winners); a focus article on flexible honeycomb-structured films that can be employed in biological contexts (from the second Treloar Prize winner Luke Connal),[4] while a further review contributed by Alain Buléon and his colleagues is focussed on the self-association and crystallization of amylase,[5] the linear component of starch. Equally important is a perspective on processing methods for variable polymers, which has been provided by Andreas Greiner and Joachim Wendorff (who gave a keynote lecture) and coworkers on the example of electrospinning of nanofibres.[6] Helmut Ritter and Sebastian Sinnwell,[7] meanwhile, have fused the application of microwave technology with polymer synthesis in the reach for ever more convenient and faster throughput synthetic approaches to polymers. The review highlights effectively what microwave synthesis is capable of and one would hope that its usage will increase in the wider polymer community.

In keeping with the theme of providing a focus on fundamental investigations, these were strongly represented at the 29th APS. Innovative fundamental methods of polymer characterization (such as high-resolution soft ionization mass spectrometry and multi-dimensional chromatographic techniques) coupled with new approaches to tackle long-standing problems in polymer reaction kinetics and mechanisms are key to designing even more efficient synthetic protocols and controlling reagents that will lead and are leading to highly defined complex polymer structures. A highlight of such fundamental studies was provided by Michael Buback[8] and colleagues, who cover the measurement and complex world of chain-length-dependent termination phenomena, while a foray into the intricate complexities of conventional free radical polymerization is provided by Greg Russell and Hans Heuts.[9] Both Buback and Russell in their talks at 29th APS stressed the importance of understanding both reaction kinetics and radical selectivities. Attempts to push the boundaries of living free radical – in this specific case reversible addition–fragmentation chain transfer (RAFT) polymerization – to new extremes have been provided by Markus Busch and the Centre for Advanced Macromolecular Design (CAMD) in their exploration of whether high-pressure ethylene polymerization with living characteristics might just be possible.[10]

Professor and ARC Australian Professorial Fellow Christopher Barner-Kowollik – currently leading a large research group at the Centre for Advanced Macromolecular Design (CAMD) at the University of New South Wales – studied chemistry at the Universities of Konstanz and Göttingen in Germany. He completed a Ph.D. in Physical Chemistry at the University of Göttingen, before joining CAMD/UNSW. He has published over 130 peer reviewed papers, over 120 conference papers and 7 book chapters on conventional and living free radical polymerization, ranging from fundamental mechanistic and kinetic investigations to complex architecture polymer synthesis and polymer characterization. He is the editor of the Handbook of RAFT Polymerization *(Wiley VCH 2007) and has received several awards for his work, including the* Rennie Medal *of the Royal Australian Chemical Institute and the* Edgeworth David Medal *of the Royal Society of New South Wales. Professor Barner-Kowollik was the Chair of the RACI Polymer Division as well as the Chair of the 29th Australasian Polymer Symposium.*

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The Australian-invented RAFT process and its mechanism received (again) a large amount of coverage at the symposium, and its potential to generate well-defined and complex polymer architectures (especially in conjunction with highly orthogonal and efficient *Click* chemistry) was impressively highlighted. Sébastian Perrier and his team take a close look at trithiocarbonate-mediated RAFT acrylate polymerizations to systematically probe the reaction parameters affecting the polymerization.[11] Michelle Coote and her colleagues have in recent years opened up high level *ab initio* molecular orbital calculations with high accuracy to the field of living (and especially RAFT) polymerization with enormous success. In the current special issue, they demonstrate the practical use of fundamental quantum mechanical calculations. They show that *ab initio* quantum chemical calculations can be efficiently employed to predict a novel route to the radical ring-opening polymerization of phosphetanes to polyphosphines, with the aim of incorporating phosphorus atoms into polymer backbones to improve their polarity and metal-binding characteristics.[12] In an example of fundamental polymer physics in action, John Torkelson and his team investigate the effects of nanoscale confinement and interfaces on the glass transition temperature of poly(n-methacrylates).[13]

The 29th APS and this special issue of *Australian Journal of Chemistry* thus demonstrate the importance of maintaining a balance as well as an efficient feedback loop between fundamental approaches and applications- (and sometimes commercially) driven research, focussing on fields such as polymer-based drug delivery, optoelectronics, or tissue engineering. Only in a close collaboration and genuine teamwork between quantum chemists, kineticists, groups focussed on polymer characterization, biologists as well as materials scientists and biomedical engineers can we hope to generate truly effective materials.

Finally, it is worth highlighting the fact that the current special issue is the fourth devoted entirely to polymer science (based on Australasian Polymer Symposia), a pattern that began with the hugely successful 2002 volume. The Polymer Division is very pleased that the *Australian Journal of Chemistry* and its enthusiastic editor Dr Alison Green show such a keen interest in polymer science as well as strong and long-standing support for the APS conference series, both through publication of these issues as well as through sponsorship of the Treloar Prize. It is hoped that the current special issue will not only find resonance among polymer scientists, but also in the wider chemistry community. Thanks for reading.

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