Cooperative Research Centre for Polymers
Solutions for a better world

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News from the CRC for Polymers

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Welcome

"Collaborative research at the interface of polymer science and biology is likely to lead to many technologies that will benefit society."

in this issue

CRC AUSTRALIA

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Polymers for high technology developments in biotechnology

Polymer science and engineering is an area of great research strength in Australia. The CRC for Polymers (CRC-P) has assembled multidisciplinary teams of polymer researchers drawn from ten universities, CSIRO and ANSTO to carry out research projects with scientists in other areas of research and economic strength in the economy.

Research in the Centre's program on *Biomedical polymers* impacts on the biotechnology sector, and is primarily focused on two major activities. The first involves creating polymer surfaces that contain biological information and interact with cells to control cell function. The second involves developing a novel delivery technology to make it possible to have a single injection

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Some of the CRC-P's Biomanufacturing Consortium team

Biomanufacturing Consortium assisting in tackling blood supply crisis

The CRC for Polymers has assembled a multi-skilled team of scientists to assist the Australian Stem Cell Centre (ASCC) which is developing a new way of manufacturing blood and other cell-based products for transplantation.

The key technical challenge for the team is to develop an artificial mimic of the natural environment in which stem cells reside in the body. This "smart surface" needs to contain the full array of information normally provided to cells in their natural biological environment, but be embedded into a polymer substrate that can be easily manufactured at high volume and low cost.

The research team, called the Biomanufacturing Consortium, brings together established research groups from the ASCC, CSIRO Molecular and Health Technologies, Monash University's Centre for Green Chemistry and Materials Engineering Department, and Swinburne University of Technology, to develop a new platform technology of smart polymer surfaces that control cell function and fate. Eventually the ASCC will use these smart surfaces in bioreactors to manufacture blood products and cells for transplantation.

The research team brings complementary expertise in engineering, material and biological sciences,

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Biopolymer-based system for single dose vaccine delivery

Left to right: Dr John Walker, A/Prof. David Jackson and Prof. David Mainwaring

Practical controlled delivery of therapeutics is a challenging area of research for both animal and human health. Preparation of single dose vaccines is challenging because of the requirement for both an initial pulse release of vaccine at injection and the need for a further delayed pulsed release at one or more months later.

The CRC-P, in partnership with Pfizer, is undertaking a project to develop animal health vaccine delivery systems based on biopolymers as vehicles for incorporation of the vaccine and its release according to a designed time profile.

Professor David Mainwaring of RMIT says, "The qualities needed for such a delivery vehicle include biocompatibility, enzymatic biodegradability and non-toxicity. Products of degradation, in particular, need to be non imunogenic and non carcinogenic natural metabolites,". Already the project has demonstrated the production of suitable biopolymer based systems with the required microstructures that can accept the loadings of a vaccine typically used in the agricultural industry. The researchers recently completed the first small animal safety and efficacy trial.

The RMIT team is focusing on the biopolymer chemistry, interactions between the polymer chains and antibodies and the formulation of injectable delivery vehicle dispersions. Professor Mainwaring, who leads the RMIT team, holds a doctorate from the Imperial College of Science, Technology and Medicine, London, and is the Professor of Applied Chemistry at RMIT. He has been active in the areas of biosensing technologies, the flow and stability of pharmaceutical formulations and the production of biopolymer thin films and nanoparticles for a range of diagnostic and delivery applications.

Another part of the team is based at the University of Melbourne, led by Associate Professor David Jackson. The team have a well recognised history in immunology and vaccine development, and are focussing on the mechanisms of the immune response of these systems.

Dr John Walker leads the team members from Pfizer who provide expertise on the animal vaccines and guidance on the technical and commercial requirements of the delivery system.

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Polymers for high technology developments in biotechnology

vaccination for cattle, rather than needing to provide a second booster injection at a later date. This issue of Polymer News contains further information on both these projects.

The technologies being developed are made possible because of the major recent advances that have occurred in many areas of materials science. Examples include unprecedented control over the design and synthesis of polymers (i.e. their molecular weight, precise composition and architecture), realisation of new properties resulting from nanotechnology, and powerful characterisation techniques (including nuclear scattering techniques) that provide guiding structural information on a wide range of scales.

Polymer science can now design materials with properties tailored for a diverse range of uses in biotechnology, and collaborative research at the interface of polymer science and biology is likely to lead to many technologies that will benefit society. Examples of commercial products resulting from the activities of other Cooperative Research Centres include Ciba Visions' Night & Day extended wear contact lens (CRC for Eye Research and Technology) and a biocompatible silicone-urethane copolymer (CRC for Cardiac Technology) which is now being sold by Aortech International for use in implanted medical devices.

The CRC for Polymers is looking to expand its research activities on biomedical polymers by working closely with biotechnology companies seeking polymers with properties tailored for their specific needs.

Moldflow software to include enhanced predictive capability

Left Mr. Robert Trenberth (APPL) and right Dr Peter Kennedy

Moldflow and Advanced Polymerik have jointly announced an agreement that will see the results of a collaborative research project incorporated into Moldflow's injection moulding software. The project was conducted in the CRC-P during the previous funding period (1999-2005). The technology will enhance a Moldflow product that allows the designer of an injection moulded part to optimise its structural performance. The calculations take into consideration both the specific properties of the selected grade of polymer and the process-induced flow characteristics which determine the microstructure induced in the final product.

The CRC for Polymers has assembled a multidisciplinary research team of scientists and engineers from Moldflow, The University of Sydney, Monash University and the Australian Nuclear Science and Technology Organisation (ANSTO) to develop this major advance in component design. Professor Roger Tanner FRS and Professor Xijun Fan at The University of Sydney developed the new mathematical models required for predicting how a cooling molten polymer changes its flow behaviour and crystallises under the range of flow conditions experienced in the process. Associate Professor Graham Edward and Dr Peng-wei Zhu, from Monash University, collaborated with Dr Robert Knott from ANSTO to precisely characterise the effect of different processing conditions on the resulting microstructure across moulded components using synchrotron experiments. The team also developed the understanding required to relate complex microstructures to the overall structural performance of the part. Dr Peter Kennedy, Moldflow's Executive President and Chief Technology Officer, guided the research and Dr Rong Zheng from Moldflow implemented its findings into Moldflow software.

Mr Robert Trenberth, the Executive Chair of Advanced Polymerik, noted: "The development of the scientific understanding behind the enhanced software took six years of research by a large team, and several more years to implement and verify in the enhanced software. This long lead time, from the start of a project to a major commercial outcome, underscores the need to have an organisation like Advanced Polymerik to actively manage technologies arising from a CRC, beyond its given seven year period funding, to complete the commercialisation of its technologies and maximise the resulting benefits for both its stakeholders and society."

Moldflow was established in Melbourne 30 years ago and this remains the base for its largest research laboratory. It is now the dominant global supplier of software for injection moulding, a process which is used to make approximately one third of all plastic products.

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Biomanufacturing Consortium Assisting in Tackling Blood Supply Crisis

encompassing protein and synthetic chemists, stem cell biologists, polymer scientists, coatings experts and engineers. The Biomanufacturing Consortium has been successful in attracting top quality scientists from several countries to be part of this project.

The smart polymer surfaces will be used in bioreactors for the production of transfusible blood products. They may also have applications in several industries, for example in the production of cells for cell-based therapies, or in bioprocessing, for the production of drugs from cell-based reactors. Using 'smart' polymer surfaces to control cell function, the research aims to develop a new platform technology to produce a whole range of therapeutic products which are currently sourced from blood donations.

The transfusion of red blood cells to replace blood loss and of platelets to prevent spontaneous haemorrhage saves many lives throughout the world. Blood cell products are currently obtained from donations to blood banking organisations such as the Australian Red Cross Blood Service or the American Red Cross.

Internationally, the blood banking industry faces an impending crisis catalysed by the decreasing rate of blood donation due to an increase in exclusion criteria, more comprehensive testing for safety criteria, and limitations of storage leading to outdating of an already limited supply.

The Biomanufacturing Consortium is the largest research project undertaken within the CRC for Polymers and has been further supported by a $1.5 million injection of funding from the Victorian Government as part of its initiatives to foster the growth of the biotechnology industry in the State.

CSIRO provides extensive expertise in biomaterials


Dr Keith McLean

CSIRO Molecular and Health Technologies is one of the organisations collaborating in the Centre's research project targeted at developing smart polymer surfaces for controlling cell function. Its scientists have an enviable track record of developing fit-for-function biomaterials, and understanding their interactions with biological systems by combining skills in chemistry, materials science and biology.

Its researchers contribute a wide range of expertise to the CRC-P's research project including polymer chemistry, surface science, medicinal chemistry, molecular biology and cell and matrix biology.

CSIRO's Dr Keith McLean is one of the Biomanufacturing Consortium project leaders and within CSIRO he is the Theme Leader for Biomaterials and Regenerative Medicine. The Theme's two major priorities are biocompatible materials and scaffolds, and cell and tissue therapies. The field of scaffolds for tissue engineering has significant potential to contribute to medical therapy by enhancing tissue regeneration. The aim is to produce material which will replace lost or damaged tissues. Keith notes: "Medical therapies based on tissue engineering require a material that is truly biocompatible, able to deliver the required biological information, and eventually degrades, leaving a native tissue replacement."

Previously Keith worked in the CRC for Eye Research and Technology, developing surface coatings for an implantable contact lens, and became project director of the Vision CRC in 2002. The Implantable Contact Lens project won The Royal Societies of Australia Eureka Prize for Multidisciplinary Research in 2004 and is currently in a Phase 1 clinical trial.

Researcher contributes knowledge on molecules of the extracellular matrix


Dr Julie Nigro

Julie Nigro, a postdoctoral fellow with the CRC-P's Biomanufacturing Consortium, is contributing her knowledge on molecules of the extracellular matrix.

After completing a PhD on the effects of fibrates (triglyceride lowering agents) on proteoglycan synthesis and structure in human vascular smooth muscle cells, Julie worked at the Cleveland Clinic in Ohio, where she continued to study chemically modified synthesis of the extracellular matrix proteoglycans by airway smooth muscle cells. Her work has applications for therapeutically reversing the constriction of airways that occurs in an asthma attack.

Julie was attracted to the position at the CRC-P as a way of entering the exciting field of stem cell biology and also because it allows her to extend her research to other molecules of the extracellular matrix.

"We are looking at increasing the production of blood-forming stem cells. Blood-forming stem cells reside in the bone marrow so we are looking at what sort of extracellular matrix proteins are in that environment or niche," Julie explains.

"We are using some extracellular matrix proteins that we have detected in this stem cell niche and putting them in a culture system with the stem cells. Already we are finding that some of these proteins are causing the numbers of stem cells to increase."

One of the difficulties with this work is maintaining stem cells in the undifferentiated state. It is very hard to grow stem cells because they occur in low frequency and once in culture they tend to differentiate into their different lineages, such as neutrophils, macrophages and red blood cells.

"The main challenges are understanding the structural (extracellular matrix) and chemical cues for controlling stem cell fate."

Julie works in a laboratory at CSIRO Molecular and Health Technologies with Dr Werkmeister and Dr Ramshaw and with Dr Nilsson and Dr Haylock at the Australian Stem Cell Centre.