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Centers of Polymer Research

## Polymer Science In Australia II. Brisbane And Queensland

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### Introduction

Queensland is one of the 6 states of Australia and about three times the size of Texas. It is the second largest state of Australia with an area of about 670,000 square miles and a population of about 3 million people; it reaches to a latitude of 10° south of the equator, reaching into the tropics, although much of the state is arid. Brisbane, the capital of the state, also called the river city, is located in the southeast corner of Queensland and is the home of

about 1.5 million people. Brisbane was founded after the landing of the settlers in Moreton Bay in 1823.

### University Of Queensland

The University of Queensland is the largest institution of higher learning in Queensland in the northern part of Australia; it was founded in 1909 and is now located on 115 hectares of riverside parkland about 7 km from the Center of the City of Brisbane in St. Lucia. The University has 25,000 students in 63 academic departments and 15 faculties and is located on 2 campuses: St. Lucia and Graton. The University is ranked 3rd or 4th among the 36 Universities and Colleges in Australia. About 4,000 of the students are graduate students and 1,600 are candidates for doctoral degrees. In terms of grants received, the University of Queensland, with 6.0 million dollars ranks fourth behind the University of New South



*Brisbane, Australia*



*University of Queensland*



*University of Queensland, Forgan Smith Building*

Wales (10.3 million), the University of Sydney (9.9 million) and the University of Melbourne (8.6 million). In Brisbane, Griffith University has 1.5 million and the Queensland University of Technology has 0.8 million in grant funding.

#### **The Department of Chemistry**

The Department of Chemistry was established in 1910 as one of the four founding departments in the University. At that time the University was located at a site in the center of the city adjacent to the Botanical Gardens and the Parliament House.

Burtram Dillon Steele was appointed as the first Professor, and teaching commenced in 1911, with students enrolled in Science and Engineering. In 1918 a degree course in Applied Chemistry was established and, in the 1960's became a degree in Chemical Engineering, offered within a new Department of Chemical Engineering.

After the second world war, the University gradually relocated to a new and much larger site in the Brisbane suburb of St. Lucia. The Chemistry Department was moved to the new site in 1951. The original Queensland University site in the city center is now occupied by the Queensland University of Technology.

From its establishment, the Chemistry Department has offered subjects in the traditional areas of Organic, Inorganic and Physical Chemistry. In the early development of the University, polymer science was taught within organic chemistry, but in the 1960's the teaching of polymer science was expanded with the appointments of Maurice Mason and James H. O'Donnell. Over the intervening period, the teaching of polymer science and technology within the Department of Chemistry has taken on a much more important role. The Polymer Materials and Radiation Group has grown to become the largest research group within the University in Materials Engineering, Chemical Engineering and Biochemistry. The Group has also played a leading role in the development of polymer science and technology in Australia, and has an established international reputation in both teaching and research in the polymer area.

#### **Polymer Materials and Radiation Group, Department of Chemistry**

The faculty of the Polymer Materials and Radiation Group includes Professor James H. O'Donnell, Drs. David J.T. Hill, P.J. Pomery, Ian R. Gentle and Andrew K. Whitaker. It also has 4 Post-Doctoral Fellows, 2 Research Assistants and



*University of Queensland, St Lucia Campus. Glimpse Through The Western Entrance To The Great Court*



## Centers of Polymer Research

15 Post-Graduate Students. The Polymer Materials and Radiation Group is a research group within the Physical Chemistry area of the Department of Chemistry, but it has very close links with members of the Department with interests in the other areas of Chemistry. It also has close links with colleagues in other Departments, including Mining and Metallurgical Engineering, Chemical Engineering, Biochemistry, Electrical Engineering and the Center for Magnetic Resonance.

The research interests of the Polymer Materials and Radiation Group consist of:

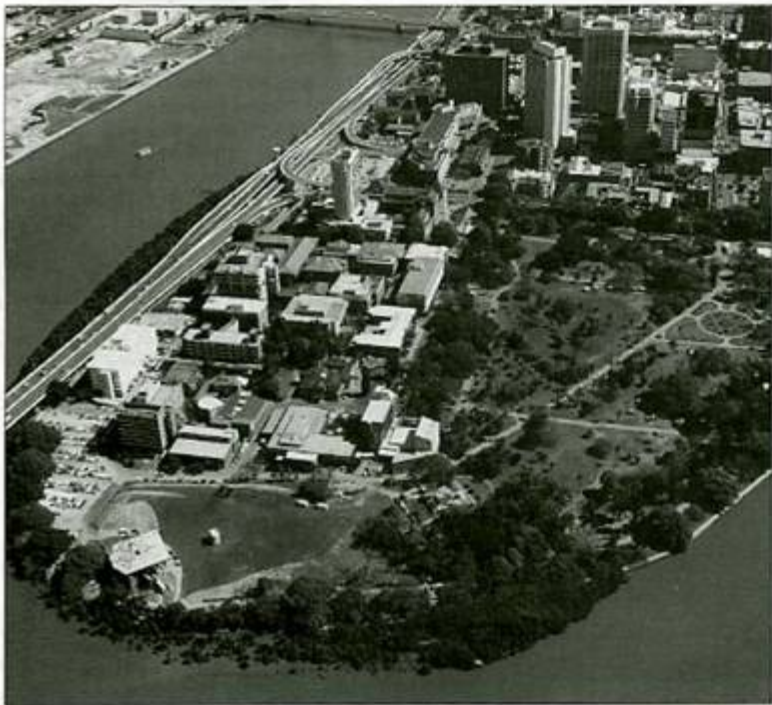
- 1.) Degradation of Polymers in Hostile Environments which includes high energy radiation, including gamma and e-beam radiation; UV and VUV radiation; plasma and atomic oxygen; high temperature exposure and the monitoring of wear behavior.
- 2.) Kinetics and Mechanisms of Polymerizations, including homopolymerization to high conversion; modelling of copolymerizations; microstructure determination by NMR; step-reaction polymerizations of epoxies and bismaleimides.
- 3.) Polymer Structure and Polymer Chain Dynamics, involving  $^1\text{H}$  and  $^{13}\text{C}$  NMR determinations, including solid state NMR, thermal, dynamic mechanical and surface analysis; FT-IR and FT-NMR spectroscopy.
- 4.) Radical Formation and Reactions in Polymers as identified by ESR spectroscopy, radical trapping and thermal annealing techniques.
- 5.) Optical and Medical Polymers with special emphasis of vinyl and allylic polymers and copolymers; hydrogels and their structure and physical properties; kinetic monitoring and modelling; polymers for controlled release applications.
- 6.) Biodegradable Polymers, including polyalkanoates, their characterization and determination of physical properties; cellulose derivatives their radiation and thermal stabilities.
- 7.) Langmuir-Blodgett Films are studied for their two dimensional structure by x-ray and neutron scattering; the formation of conducting polymers and their properties are also being investigated.
- 8.) Polymer and Copolymer Blends: Polymer fluorescence is used as a probe of polymer compatibility; NMR spectroscopy is being used to study the chain relaxation behavior and its influence of polymer microstructure.

James H. O'Donnell, Professor of Physical Chemistry is interested in a.) Radiation Degradation of Polymers and Copolymers, to measure quantitatively the changes in molecular and material properties of polymers resulting from irradiation by (i) high energy (ionizing) radiation and (ii) UV radiation. The mechanisms of degradation and the relationships between molecular structure and radiation sensitivity/resistance are being investigated. b.) Mechanisms of Free Radical Polymerization and Copolymerization are being studied with emphasis on the polymerization of methacrylate and dimethacrylate monomers to

high conversion, combined ESR measurements of radical concentrations while using NMR and IR for the determinations of conversion. The evaluation of mechanistic models for free radical copolymerization involves also considerations of penultimate effects and comonomer complex participation, using NMR spectroscopy to determine copolymer compositions and monomer sequence distributions.

Professor O'Donnell is also very much interested in chemical education, the promotion of chemistry in the profession and the community and national and international interactions in science.

David J. T. Hill, Reader in Physical Chemistry is leading the studies of: a.) Mechanisms of Free Radical Copolymerization by developing mathematical models for copolymerization with emphasis on the use of sequence distributions to discriminate between models; he is also evaluating reactivity ratios from composition and sequence information using  $^1\text{H}$  and  $^{13}\text{C}$ -NMR techniques to determine polymer microstructure and examining their structure-property relationships; b.) High Conversion Polymerization by investigating the kinetics of free radical



Queensland University of Technology



polymerizations of vinyl and divinyl monomers to high conversion and determining the time dependence of monomer and radical concentration using FT-IR and ESR spectroscopy; c.) Radiation Degradation of Polymers, by investigating the relationships between microstructure and polymer sensitivity to high energy radiations and is examining radiation induced thermal degradation of polymers and energy transfer in polymer systems.

Peter J. Pomery, Senior Lecturer in Physical Chemistry is interested in a.) Polymer Degradation which includes the development of specific techniques to detect the early onset of polymer degradation, resulting from ionizing or UV radiation. Degradation mechanisms are probed by ESR, GC/MS and GPC to monitor radical species produced; small amounts of gaseous products are being isolated and identified, and molecular weight changes observed. Not only are homopolymers studied but also copolymers and blends; b.) Polymerization Kinetics of free radical polymerization in bulk is being studied to evaluate the absolute rate parameters for a wide range of homo- and copolymerizations. A number of initiators and initiating conditions are being studied with the objective of relating polymerization conditions to polymer structure.

Ian R. Gentle, Lecturer, is investigating a.) Synthesis and Surface Properties of Polymer Surfactants during the formation of the structure of Langmuir-Blodgett films using scanning probe microscopy for the characterization for polymer film structure; b.) Determination of Structure of Polymer Films by neutron and x-ray reflectivity and grazing incidence x-ray diffraction; c.) Surface Activity and Properties of Conducting Polymers by forming thin films of conducting polymers by Langmuir-Blodgett techniques.

Andrew K. Whittaker is interested in a.) Solid-state NMR Spectroscopy of Synthetic and Biological Polymers; b.) Polymer Physics and Chemistry. Firas A. Rasoul is working on a.) Degradation and Stabilization of Polymers; b.) Speciality

Polymers; c.) Evaluation of Characterizations of Engineering Plastics.

#### **Queensland University of Technology 2 George Street, Brisbane, 4001**

Queensland University of Technology, one of Australia's largest Universities was formerly the Queensland Institute of Technology. It was recognized by the State Government as a University in 1989. As Brisbane's only central-city campus, it has built since 1965 a strong reputation for professional courses in technology, business and law, but its roots go back to the beginning of Queensland technical education in the late 19th century.

In May 1990, Queensland University of Technology amalgamated with Brisbane College of Advanced Education. The Brisbane College of Advanced Education with three north Brisbane Campuses had its origin in colleges of teacher education early this century but also included major fields of business, social sciences and the arts. Both schools had in common the role of vocational education for the professions; the new Queensland University of Technology now serves most professional fields.

The Queensland University of Technology has 23,000 students, 40% attend part-time, providing real-world perspectives in the lecture room; about 1,000 students come from abroad.

#### **School of Chemistry, Gardens Point Campus**

The School of Chemistry within the Faculty of Science is responsible for undergraduate and graduate chemistry subjects which are included in academic programs offered by the University.

The School has a complement of 24 academic, 24 technical and support staff and is headed by Professor Graeme A. George.

The working environment has undergone extensive renovations to improve student and staff facilities. The School is well equipped to teach and research chemical topics.

Research, development and testing, consulting and continuing education activities of the School are coordinated through the Research Centre for Instrumental and Development Chemistry. Research activities of this organization are concentrated in three areas: a.) Analytical Sciences, b.) Applied Organic Chemistry and c.) Material Sciences.

All the research in polymer science at the Queensland University of Technology is carried out at the Polymer Research and Development Group of the School of Chemistry.



**Koala**



## Centers of Polymer Research

### Polymer Research and Development Group, Center for Instrumental and Development Chemistry

The Polymer Research and Development Group within the School of Chemistry consists of 4 members of the academic staff, Graeme A. George, Peter Fredericks, Serge Kokot, John Bartley with on-going programs in polymer research, development and analysis, 3 postdoctoral fellows, 10 graduate students and supporting technicians. The group is collaborating with the academic staff and graduate students in the School of Electronic Systems and Electrical Engineering and is also involved in some programs involving polymers for electrical systems.

The Polymer Research and Development Group also provides consultant and analytical services for industry in the fields of identification, formulations, quantitative analysis and failure analysis of polymers, textiles and composite materials. Testing facilities for accelerated environment conditions are available at the Queensland University of Technology.

The current research and development of the group involves the study of 1.) Cure Chemistry of Thermosets for aerospace composites and electronic systems, FT-IR and Raman studies of epoxy, bismaleimide, phenolic and cyanate ester resins for thermal and photopolymerization and fiber optic spectroscopy for remote cure monitoring. 2.) Surfaces of natural and synthetic fibers are being characterized by X-ray, photoelectron, FT-IR and Raman spectroscopy and by secondary ion mass spectrometry. The studies include polyolefins, polyamides and wool following surface modification. The effect of surface modification on the properties of Kevlar, carbon, glass and ultra high modulus polyethylene fiber reinforced epoxy and phenolic composites are being investigated. DRIFT spectroscopy with chemometrics is being applied to match and discriminate processed and finished fibers, yarns and fabrics as well as new and worn textile goods. Chemometrics is also used to predict chemical and physical properties. 3.) Mechanisms of Degradation and Stabilization, the effect of mechanical, elec-

trical and environmental stress on the rate of thermal and photo-oxidation of polyolefins and composite materials. Chemiluminescence is being used to study the heterogeneity of polymer oxidation. A laboratory model has been developed to study 'catalytic damage' in cotton fabrics during bleaching with hydrogen peroxide. The binding sites and the mechanisms of the reactions of metal ions such as Cu(II) and Pb(II) with fibrous keratins are being investigated using electron microscopy, surface analysis, FT-IR and Raman techniques supported by chemometrics for the elucidation of the effects of metal ions on the fibrous proteins.

Graeme A. George, Professor and Head of the School of Chemistry is interested in the a.) Mechanisms of Degradation and Stabilization of Commercial Polymers, especially the effect of mechanical, electrical and environmental stress on the rate of thermal and photo-oxidation of polyolefins and composite materials; b.) Characterization of Organic Materials by Luminescence Techniques for polyolefins, epoxy resins and unsaturated oils during oxidation. The changes of the microviscosity during cure, moisture absorption and UV degradation deduced from the results of the kinetics of luminescence and ESR spectroscopy; c.) Network Polymerization. The kinetics and mechanisms of reactions of cyanate esters, epoxy resins and phenolics crosslinking including photopolymerization of networks are being evaluated by spectroscopic and calorimetric techniques (simultaneous FT-IR-DSC); d.) Surface Analysis of Polymers and Composites is being carried out by X-ray photoelectron spectroscopy, secondary ion mass spectrometry and FT-IR reflectance spectroscopy. Investigated are polyolefins, polyamides and wool following surface modification. The effect of surface modifications on the properties of Kevlar, carbon, glass and ultra high modulus polyethylene fiber reinforced epoxy and phenolic composites is also being evaluated.

Peter M. Fredericks, is applying vibrational spectroscopy, particularly FT-IR and FT-Raman, to the study of polymers. This work includes the study of the kinetics of polymerization

reactions, polymer degradation, as well as general polymer characterization.

Serge Kokot, Senior Lecturer in Analytical and Inorganic Chemistry, is interested in the a.) Interaction of Metal Ions with Fibrous Keratins; b.) Treatment of Cellulosic Materials with Electrogenerated Chemicals and c.) Analysis of Fibrous Materials.



Griffith University



Griffith University

Griffith University Of Brisbane,  
Nathan, Queensland, 4111

Griffith University was established in 1971, and is named to honor the Rt. Hon. Sir Samuel Walker Griffith, a former Premier of Queensland and a leading political figure at the turn of the century.



**Griffith University in Surfers Paradise**



**Red Kangaroo**

Since the first students enrolled in 1975 the University has undergone rapid growth. In 1994 the University has more than 16,000 students in the Nathan, Mt Garvatt, Gold Coast and Mackay Campuses; the Queensland College of Art and the Queensland Conservatorium of Music.

The Nathan campus, the University's original site is located on 175 hectares of natural forest which has been declared a flora and fauna reserve adjacent to the Toohey State Forest, at Kessels Road, Nathan, 10 km southeast of the Brisbane city center. The neighboring Mt Gavatt campus, formerly part of the Brisbane College of Advanced Education, and the Gold Coast campus, formerly the Gold Coast College of Advanced Education, joined the University in 1990. The Gold Coast Campus at Southport is located about 70 km from Brisbane. The Queensland College of Art joined the University in 1992.

Polymer Science at Griffith University has its home in the School of Science at the Nathan campus, Brisbane, which is the University's largest campus with approximately 9,000 students.

The research activities in polymer science are primarily under the direction of W. Ken Busfield, Associate Professor, of Chemistry in collaboration with Ian Jenkins, an organic chemist. They are interested in a.) High Energy Irradiation of Polyolefins; b.) Photodegradation of Blends Containing Polyolefins; c.) Initiation Mechanisms in Free Radical Polymerization, especially by nitroxide trapping techniques and d.) Functionalized Oligomers.

In the studies of irradiation effects on polymers, the focal points are i.) Acetylene sensitized  $\gamma$ -irradiation, crosslinking of drawn polyethylene; ii.) The influence of  $\gamma$ -irradiation on the stereoregularity of isotactic polypropylene and other polyolefins and iii.) The photooxidative degradation of polyethylene under mechanical stress. In the investigation of radical polymerization, the group is concentrating in i.) Early copolymerization kinetic parameter in systems of monomer pairs with high alternating tendency, ii.) Solvent effects on the rate constants in early copolymerization; iii.) The contrasting polymerization behavior of maleate and fumarate esters and iv.) New radical initiators based on phosphorous, sulfur and other elements.

Another project is being undertaken in collaboration with scientists of CSIRO (Chemicals and Polymers Division) in Melbourne which involves the investigation of end groups in functionalized co-oligomers produced with the aid of sulfur based chain transfer agents.

#### **Acknowledgments**

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