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Polymer Science in Australia IV. Universities in Victoria and Southern Australia

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Polymer Science In Australia IV. The Universities in Victoria

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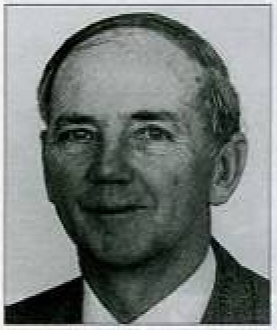
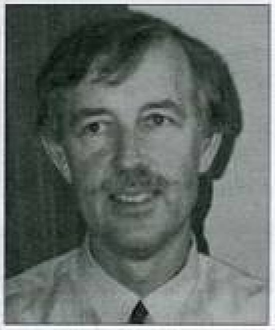


David H. Solomon



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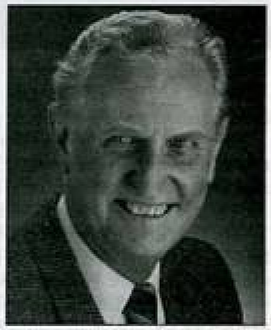

Otto Vogl

Introduction

The state of Victoria has a land area of 228,000 square kilometer and a population of 4,1000,000. After the first landing of the British in Sydney, it was decided to attempt the settlement on another part of the Australian coast and a settlement was established in 1803 on Port Philip Bay. In 1835 the first permanent settlement was made at the present site of Melbourne and shortly thereafter the place was named Melbourne. In 1851 the colony Victoria was formed and separated from New South Wales.

Melbourne is Australia's second largest city and has today a population of 3,000,000. It is the major industrial center in Australia; it is the home of three major Universities and many governmental institutions.

The University of Melbourne

The University of Melbourne, established by an Act of the Victorian Parliament in 1853, was officially opened in 1855. At the ceremony were its first three professors and 16 students. It was Victoria's first university and Australia's second.

The University has achieved much in 139 years, amply living up to its motto: *Postera Crescam Laude* (I shall grow in the esteem of future generations). It has won world recognition for excellence and achievement in education and research. Graduates and former students have earned distinction

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University of Melbourne

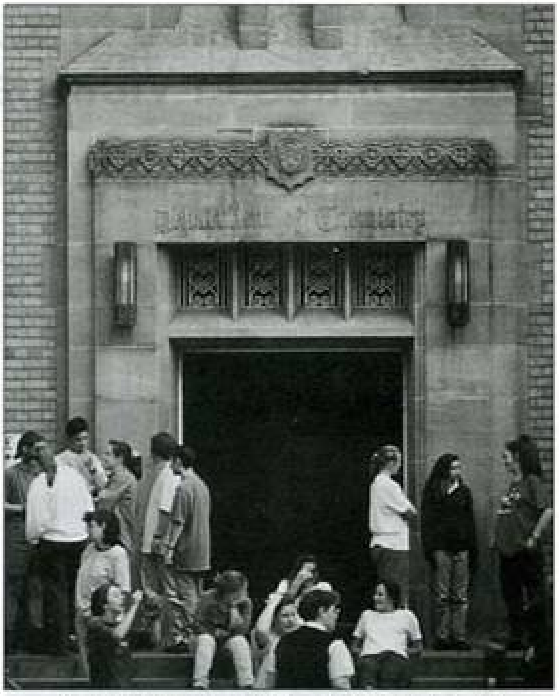
in the professions, the sciences, politics and the arts.

The **University of Melbourne** undertakes teaching and research programs for some 30,000 students, supported by almost 5,500 staff. As one of the largest Universities in Australia, it covers a very diverse range of disciplines.

The **Faculty of Science** is one of the University's largest faculties and has some 3,000 undergraduate and postgraduate students. There are four schools and seven departments, some of which include the Schools of Chemistry, Earth Sciences, Mathematics Sciences and Physics, and the Departments of Genetics, Statistics, Optometry and Zoology. The Faculty provides integrated programs of teaching, postgraduate training and community service, all of which are based on a solid foundation of research in both the pure and applied sciences.

The **School of Chemistry** is one of the oldest in Australia. The first lectures in chemistry at The University of Melbourne were given in 1856. Since those early days, the School has grown and developed, and is now a large department within the University's Faculty of Science. There are about 1,800 undergraduates enrolled in Chemistry, and almost 100 graduate students enrolled in MSc or PhD programs. The School is headed by Professor D.H. Solomon, an established scientist with an international high reputation, who joined the University in July 1990 after extensive experience in industry and at CSIRO. Working in research in the School are more than 35 academic scientists. The research fields span the traditional disciplines of organic, inorganic and physical chemistry, as well as theoretical, analytical, marine, and polymer chemistry.

The School, like many organizations, has recognized the need to bring more focus to its work, and to update its facilities to match world standards. Recently, a number of changes have been made to both modernize the facilities and to focus the research efforts. This has involved progressive upgrading of the School's laboratories and equipment, and recruitment of academic scientist with a strong research profile who are expected to reinforce work in key areas. In addition, stronger links are being built with other research activities around the world and increasingly contact is being established with the end-users of much of the research, i.e. industry.



At the Campus of University of Melbourne

The **Advanced Mineral Products Research Center**-AMPC-(an Australian Research Council Special Research Center), is an interdisciplinary initiative between Chemistry, Chemical Engineering and Applied Mathematics, and has its central office and management team located in Chemistry. This Special Research Center, one of only 2 at the University of Melbourne, and 20 nationwide, is a major grouping of staff and research students. The focus of the Center is towards basic research in support of the value-added product goals of the Australian Minerals Industry.

The **School of Chemistry** is keen to develop stronger links with industry in the area of collaborative research. The School sees the benefits of this as follows: A.) to provide challenging research at the PhD level; B.) to link research to industry end user and C.) to assist industry to resolve problems/improve processes over the longer term and, therefore, to build or to retain its competitive position.

The School currently does collaborative research with a number of industry partners in the oil, mining, and chemical sectors. These partners include Comalco Aluminum Ltd., ICI Australia Limited, Dulux Australia, Gradipore Ltd. and Sola International Holdings Ltd. The research takes a variety of forms, from support of a PhD research student on a nominated project, to setting up collaborative teams of researchers from industry and the University, with equipment and support staff.

There are a number of mechanisms in place to encourage collaborative research between the University and Industry. These include significant grants from Government which puts matching funds into research behind industry and University money, and scholarships for students working on industry issues.

The **School of Chemistry** at the **University of Melbourne** has, for many years, had a broad interest in Polymer Science. Aspects of Polymer Science were taught as parts of a wide variety of courses, for example, kinetics and mechanism, industrial chemistry, and inorganic networks. In recent years and with the appointment of Professor Solomon as Head of the School, the teaching and research have become much more focused. All students study Polymers in the third year and , in the Honors course, Polymer Science is a compulsory subject.

The main research groups are focused on the *Photophysics of Polymers, Mechanistic studies* which aim to relate the synthesis, structure and properties, new organic/inorganic macromolecular structures and interfacial studies. Most of these areas attract significant support from Australian industry and from Government research granting bodies.

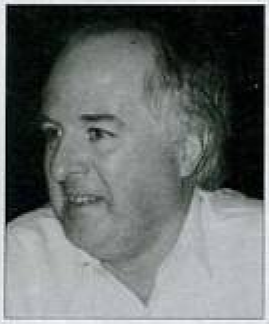
The number of students electing to study for higher degrees in Chemistry where the research thesis is polymer related has increased dramatically in the last five years. At present, there are approximately 20 PhD and 5 Honors students studying polymer related topics.

Polymer Science at the University of Melbourne

Polymer science at the University of Melbourne is concentrated in the School of Chemistry, whose head is ***David H. Solomon***, ICI Aust.-Masson Professor of Chemistry. He is interested in the synthesis of new monomers for use in optical lenses, particularly, the synthesis of unsaturated molecules which will produce improved lenses over the currently used diallyldiethylene glycol carbonate type materials. The chemistry of phenol/formaldehyde/furfuryl alcohol systems used in the manufacture of aluminum is also being studied. These investigations range from attempting to detail the chemistry that occurs between the three components and relating this to structure in the final graphitized cathode.

The detailed mechanism of free radical polymerization, in particular, methacrylonitrile and cyano radicals and their ability to react through either the carbon or nitrogen radicals is being studied. Novel cross linkers for polymers used in electrophoresis are being investigated; this work involves the synthesis of new cross linkers for acrylamide, the preparation of electrophoresis gels, the correlation with structure and the ability of these gels to separate proteins. Synthesis of microgel polymers and their properties is also being studied.

David Solomon was also involved in the development of the new A$ 10 polymer note which was designed by the Melbourne based designer Max Robinson.


Kenneth P. Ghiggino

Kenneth P. Ghiggino, Associate Professor and Reader is interested in Photophysics and Photochemistry of Polymers, in the study of energy relaxation, conformation and mobility in natural and synthetic macromolecules, in photopolymerization processes and in techniques that include picosecond and femtosecond spectroscopy, fluorescence, FTIR, Raman and laser light scattering. His most recent investigations include the mechanisms of energy migration, excimer formation and energy trapping in photoirradiated aromatic polymers. Studies of polymer-polymer interdiffusion using fluorescence probe techniques are also of great interest as are the investigation of molecular motion in polyelectrolytes and polymer complexes using time-resolved fluorescence anisotropy measurements and the interaction of inorganic ions with polyelectrolytes, the photopolymerization of dimethacrylates and the photodegradation mechanisms of acrylic coatings.

Graeme J. Pratt is studying molecular and segmental motions in solid polymers, their correlation with physico-chemical structure, UV-radiation and environmental factors. Investigations of the dielectric properties of solid polymeric materials, especially of commercial polycarbonate homopolymers and blends are of particular interest.

The Royal Melbourne Institute of Technology

The ***Royal Melbourne Institute of Technology*** (RMIT) was established in 1887. The main campus is in the center of Melbourne with another major campus at Bundoora (20 km north-east) in addition to smaller campuses. With its combined campuses it has the largest student population (40,000 students) of the Australian universities. It is currently (1994) the University with the highest number of first and total preferences for new student applications in Victoria. RMIT's distinctive mission


A$ 10 Polymer Bank Note

RMIT

Royal Melbourne
Institute of Technology

RMIT from Swanston Str. Faculty of Applied Science

commits it to being a university at the forefront of technical and professional education that develops people for employment, and to undertaking research programs that address real-world issues. RMIT has a tradition of vocationally oriented courses and applied research in the areas of science and engineering. Many projects are carried out in collaboration with industry and there is extensive technical consultation with industry. The city campus is closely linked with the central business district and downtown shopping precinct of Melbourne.

Polymer research at RMIT is a joint activity of the Applied Chemistry Dept (thermal analysis, FTIR, NMR, microscopy, simulation and physical properties), Polymer Technology Centre (injection molding, extrusion, torque rheometry, other processing and testing) and Rheology and Materials Processing Centre (steady state and dynamic rheology). Personnel consist of 7 academic staff (Professors Sati N. Bahttacharya and Edward I. Kosior, Associate Professor Robert A. Shanks, Arthur P. Francis, Graeme Churchward, Dr. Chattarong Boontanji and Dr. John O'Donnell), 5 research fellows (Dr Graeme J. Field, Dr Don Perera, Dr. Long Yu, Dr Feras Rasoul, Andrew Chryss), 2 technical officers and 30 graduate students. RMIT polymer researchers are members of the Cooperative Research Centre for Polymer Blends, an Australian Government and industry funded special centre. Other polymer research at RMIT is undertaken by Aerospace Engineering, Design, Mechanical Engineering, Applied Physics and Textile Departments.

Current research areas are: polymer blends especially blends of polyolefins and the application of compatibilizers, toughening mechanisms, morphology and rheology, synthesis of modified hydrogels, surface modification of recycles crumb rubber and extrusion of form reverse rubber composites, computer simulation of polymer properties, synthesis and rheology of branched polyesters, synthesis of amphoteric ion exchange resins, and absorptive polymeric sensors using piezo electric quartz.

Special projects are undertaken for the polymer industry on a regular basis. Companies are involved in close collaborations for individual projects or in longer term strategic alliances. A very large number of short term projects and contracting of facilities take place with industries all over Australia. Short courses in processing of polymers, polymer rheology, thermal analysis, and near infrared spectroscopy and molecular spectroscopy have recently been held.

Robert A. Shanks, Associate Professor of Polymer Science, in conjunction with Arthur P. Francis, Dr Don Perera and Dr Long Yu, is investigating microstructure and properties of polymers, polymer blends and alloys, thermal analysis, microscopy and FTIR of polymers, synthesis of modified hydrogels, sensor polymers and specific ion exchange resins, computer simulation of polymers and their properties. Some of their many projects include preparation of new polypropylenes with increased toughness, video image analysis of polypropylene crystallization, grafting of synthetic polymers into wool and atomic force microscopy of wool fibers under various environments.

Sati N. Bhattacharya, Professor of Chemical Engineering, in conjunction with Dr. Graeme J. Field, Dr. Chattarong Boontanji and Dr. John O'Donnell, is involved in the study of polyolefins and polyolefin blends and their rheology. Of particular interest is extensional rheology of polyolefins and its application to blown film extrusion. Accelerated degradation of polyolefins, reactive processing and the crosslinking of polyethylene are other research activities. The rheology of group rubber filled polyolefins is being studied as part of a cooperative project.

Edward I. Kosior, Director of the Polymer Technology Centre, in conjunction with Dr. Feras Rasoul and Graeme Churchward, is examining processing of polymers by injection molding and extrusion, computer modelling of processing, melt rheology of polymers.

Graeme J. Field is involved in the study of polyolefins and polyolefin blends, their polymer rheology (including extensional rheology) and the processing of polymers. His other interests include accelerated degradation of polyolefins, reactive processing, blown film extrusion of polyethylene and the crosslinking of polyethylene.

Specific projects include stress whitening resistance of polypropylene, recycled tire crumb as a filler in thermoplastics, recycling of polymers, and technical consultation for industry.

Monash University

Monash University was established by proclamation under an Act of parliament of Victoria in 1958. It was named after Sir John Monash (1865–1931), a distinguished engineer, lawyer and soldier who commanded the Australian Forces in France in World War I. As a scholar and a man of action he exemplified the University's motto, *Ancora Imparo*, a saying attributed to Michelangelo that means "I am still learning".

When teaching began in 1961, the University consisted of the faculties of Arts, Economics and Politics, Engineering, Medicine and Science. The faculties of Education and Law were added later.

From the initial enrollment of 363, the University's student

Monash University

population grew rapidly. By 1966 it had reached 6,000 and by 1972 it was 12,000. in 1990 Monash merged with Chisholm Institute of Technology (now the Caufield Campus) and the Gippsland Institute of Advanced Education (now Monash University Gippsland campus). In May 1992 the University merged with the Victorian College of Pharmacy.

Today Monash has more then 40,00 staff and students on its campuses at Clayton, Caulfield, Peninsula (Frankston), and Parville (Victorian College of Pharmacy). It has 10 faculties: Arts, Business and Economics, Engineering, Law, Medicine, Pharmacy, Professional Studies and Science.

Department of Materials Engineering

The Department of Materials Engineering at Monash University was established in 1970 as Australia's first department in that branch of Engineering. In 1991 the Department comprised of 14 full-time academic staff, 15 support staff, 8 research fellows, 40 graduate students and 80 undergraduates. In 1989 the Department was instrumental in establishing a Center for Advanced Materials Technology.

Cooperative Research Center for Polymer Blends

Department of Materials Engineering, Monash University, Wellington Road, Clayton, Vic 3168

Alastair McKee, Director; ***Alan Robinson***, Assistant Director.

The Center has been established by the Federal Government as the national focus for excellence in research, technology and education in the field of polymer blends and alloys. The Center combines the resources of the CSIRO Division of Chemicals & Polymers, Monash University Materials Engineering Department, RMIT Faculties of Engineering and Applied Science and the School of Mechanical Technology, ICI Operations Pty Ltd., Huntsman Chemical Company Australia Limited, DSTO Australia (Materials Research Laboratory), Cray Research (Aust) Pty. Ltd. and the Plastics Industry Association Inc.

The Center is providing a focus in Australia for the development of advanced polymer blends, processing technologies and skills encompassing the whole product life cycle.

The main program areas are: 1.) The design and production of polymer blends components, including the synthesis of compatibilizers needed to achieve the desired alloying effects and the development of novel polymers with specific properties to be blended with commodity materials. 2.) Processing and properties of polymer blends, investigation of microstructures, flow behavior, effects of flow on development of morphology including dependence on compatibilizers and other components; computer aided techniques in polymer blend technology. 3.) Recycling and environmental control, designed to reduce the amount of polymers going to waste by developing reuse strategies; and 4.) A multi-faceted education program that supports the Australian polymer industry, seeks to develop Australian scientific capacity strengthens linkages between industry and research bodies.

Department of Materials Engineering, Polymer Materials Science and Engineering Group

A Polymer Group exists within the Department of Materials Engineering which also has mettalurgical, ceramic and corrosion engineering, fracture and plasticity, and electron microscopy groups. The Department is involved in undergraduate teaching, continuing education research, consulting work and cooperative research with the CRC for polymer blends work. In 1993, the group activities included the following scientists: ***W.D. Cook, M. Forsyth, A. Goodwin, G.H. Edward, G.P. Simon, A.J. Hill.***, 12 Postgraduate Research Scholars, 3 Research Assistants.

The research activities are in a.) Blends of engineering polymers, including main chain liquid crystalline polymers; b.) Stress relaxation in cross-linked polyethylene; c.) Mechanical applications; d.) Structure morphology relationships in crystalline polymers; e.) Toughening of thermosetting and thermoplastic polymers; f.) Adhesion of low surface energy materials; g.) Wear of polymers (polyurethanes).

Other areas of research include: Side-chain liquid crystal polymers (synthesis, dielectric/optical, devices); Coatings for mid-infrared optical fibers; photopolymerization kinetics, kinetics of network formation, solid polymer electrolytes, solid state NMR, free volume in polymers, stress corrosion cracking in polymers, dielectric properties of polymers, biomedical polymers, particulate-filled polymers, non-linear optical polymers, conductive composites.

Physical aging of glassy polymers, high performance polymers, including PEEK blends are also being studied.

Kevin R. Chynoweth, Senior Lecturer in Chemistry is interested in Polymer Blends Studies of miscibility and partial miscibility in blends; synthesis and characterization of compatibilizing agents and their reactions with blend components and analogues; crystalline phases in blends and the influence of partial miscibility on crystallization behavior.

He is also working on Properties of Thermoplastics Polyurethane Elastomers; synthesis and characterization of polyurethanes with behavior of polyurethanes and chemical modification of polyurethane elastomers for improved mechanical behavior. In Polymer Degradation his group is investigating the volatile products from polymer combustion using GD-MS, GD-FTIR and application to domestic materials.

Graham H. Edward, Senior Lecturer in Materials Engineering is investigating a.) Mechanism of Deformation and Fracture in Polymers, the development of microstructure based models relating stress, strain rate, temperature and microstructural parameters in order to predict the mode of deformation, damage and fracture of a polymer under a given set of conditions. Experimental testing of polymers, varying crystallinity, plasticizer content, etc. to compare theoretical predictions with observed behavior; b.) Design and Visoelastic Materials, the use of visoelastic spectra to model material behavior with regard to post mold shrinkage and final mechanical properties; c.) Polymer blends, the characterization of the phase structure in polymer blends using techniques of SAXD and DSC, and the relationship of properties of blends to structure; d.) Processing and Treatment of High Stiffness Fibers, the production and post-drawing treatment of high stiffness polymeric fibers, and their utilization in composites; e.) Fracture Characterization of Ductile Polymers, the investigation of fracture prediction in thin shell polymer articles and the appropriate characterization of these materials.

Wayne D. Cook, Senior Lecturer is working on a.) Network Formation, the study of polymerization kinetics and correlation with mechanical properties; kinetic modeling of network formation, particularly diffusion controlled regions; characterization of pre-gel and network structure using sol-gel; degradation analysis and rheology; b.) Polymer Blends, the correlation of blend morphology with thermal behavior and processing rheology; c.) Rheological and Relaxation Behavior of Polymers, the relation of rheological and visoelastic parameters to polymer architecture; identification of molecular motions involved in viscoelastic processes; effect of crosslinking on properties; d.) Photopolymerization, spatial effects of non-uniform irradiation; photopolymerization kinetics and mechanisms; e.) Fracture, measurement of fracture toughness and relation to molecular structure and morphology; f.) Biomedical and Dental Polymers, the correlation of structure with properties associated with the intended application.

Andy A. Goodwin, Lecturer in Materials Engineering is working on a.) Physical Aging of Polymers, the experimental observation of structural relaxation in glassy polymers using calorimetry, stress relaxation and creep; comparison of experimental behavior with theoretical predictions of relaxation parameters; effect of structure and morphology on physical aging. b.) Polymer blends, the investigation of blend miscibility and the analysis of experimental data using various equations relating Tg to composition; structure/property relationships in polymer blends. c.) High Performance Polymers, use of high performance thermoplastics and the thermosets in automotive and aerospace applications curing of bismaleimides and processing of composites by resin transfer molding.

George Phillip Simon, Senior Lecturer in Polymer Science and Engineering is investigating: a.) Polymer Blends, the mechanical, morphological and rheological properties of a range polymer blends including components such as polyolefins, liquid crystalline polymers, polyurethanes, polycarbonate and engineering polymer blends; in general he is interested in the molecular relaxation properties of miscible, immiscible and compatibilized blends (dielectric and dynamic mechanical analysis) and in the effects of aging and annealing, he is also interested in free volume measurements; b.) Liquid Crystalline Polymers, the investigation of both main chain and side-chain liquid crystalline polymers.

Main chain LCPs is being investigated are commercial materials and the relationship between rheology-morphology processing is being investigated. In addition their properties as blends (compatibilized and uncompatibilzed) are being examined. Sidechain Liquid crystalline polymers for optoelectronic uses (non-linear optics, optical information storage) are being synthesized and studied with thermal, optical and dielectric techniques; c.) Particulate Polymer Composites; composites with ceramic particles are being examined for two main applications—as biomedical prostheses and as passive damping devices for machinery; d.) Toughening of Thermosetting Systems; thermosetting systems (predominantly epoxy and unsaturated polyester resin materials) are being toughened by the addition of thermoplastics, core-shell polymers and by copolymerization. In addition, cure monitoring of these materials is being done by dielectric, thermal, dynamic mechanical and near-IR spectroscopy to understand the developing network structure as a function of cure conditions.

Anita J. Hill, Senior Lecturer is investigating the physical aging mechanism in glassy polymers. She is studying particularly: a.) Free Volume in Polymers using positron and annihilation lifetime spectroscopy to examine free volume in homopolymers and blends; examining interfacial free volume in semicrystalline polymers and immiscible blends and comparing the relationship of free volume, chain mobility and properties; b.) Morphology of Phase Separated Polymer Systems, investigating the effects of chemistry and thermal history on the morphology of phase separated systems using small and wide angle x-ray scattering, transmission electron microscopy, ^{1}H and ^{13}C solid state nuclear magnetic resonance, differential scanning calorimetry and positron annihilation lifetime spectroscopy to determine the relationship of morphology and mechanical properties; c.) Stress Corrosion Cracking of Reinforced Polymer Resins, examining the effect of cure history on fracture toughness and environmental stress cracking in resins and composites; d.) States of Water in Polymer Gels, examining free and bound water in polymer hydrogels to relate the states of water to the gel properties.

Maria Forsyth, Lecturer is interested in conductivity and dielectric properties of both ionic and electronically conducting polymers and composites. Computer simulation of molecular structures and dynamic, nucleation and crystallization kinetics in polymers and unstable glasses are also being investigated. Work in the area of conducting polymers is focusing on an understanding of the ionic conduction mechanism in polymer

Melbourne

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Center for Advanced Materials Technology

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Acknowledgement

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