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Polymer Science and Technology for the 21sth Century

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Conference Report

Polymer Science And Technology For The 21st Century

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On November 9-10, 1992 an International Symposium entitled "Polymer Science and Technology for the 21st Century" was held at the Plaza Hotel in New York honoring Professor Otto Vogl on the occasion of his 65th Birthday. The topics covered represented the views and thoughts of leading figures from industry, academia and government from Japan, Europe and the United States.

Well over one hundred scientists gathered at the Plaza and provided considerable insight into the expected changes forecast for polymer science and science policy through the nineties and into the 21st Century. Exciting recent advances in fundamental polymer research comprised an important part of this meeting. The program and speakers reflected Otto Vogl's impact, contributions and interests in many areas of polymer science. The symposium was organized by Professors David Tirrell of the University of Massachusetts and Eli Pearce of the Polytechnic University. The organizing committee included Burt Anderson (DuPont), Russell Gaudiana (Polaroid) and Gerald Kirshenbaum (Hoechst Celanese).

Eli Pearce opened the symposium with an overview of the meeting and presented greetings from the Polytechnic University where Professor Vogl has spent the last 10 years as the Herman F. Mark Professor of Polymer Science, the first endowed professorship in Polymer Science in the U.S.. David Tirrell reviewed Otto's professional history from the time he became an instructor at the University of Vienna through his activities as a Research Associate at The University of Michigan and Princeton University. Otto Vogl then spent 14 years in industrial research at Du Pont (1956-70) where he began his work on aldehyde polymerization and where he first became interested in the stereospecificity of polymerization and in macromolecular asymmetry (helicity). He then moved to academia, first to University of Massachusetts (1970-83) and then to the Polytechnic University where he remains today.

Otto Vogl *Jane Vogl*

Ann Salamone, Chairman of the ACS's Division of Polymer Chemistry, brought greetings from the Division and traced Otto's contributions to the Division especially as chairman (1975) and, for 15 years as "foreign secretary". Similarly, Richard Turner, the Chairman of the ACS Division of Polymeric Materials, Science and Engineering brought greetings from that Division.

Takeo Saegusa, President of the Pacific Polymer Federation (PPF), explained Otto's essential and crucial role in the conception and creation of this organization, now in its 6th year, which is responsible for coordinating polymer science in the Pacific Basin. Otto Vogl was the first president of the PPF, and it was under his tenure that the first PPF Conference was held in Maui, Hawaii (see also POLYMER NEWS, Vol. *15*, 191 (1990).

Koichi Hatada, the Vice President of the Society of Polymer Science, Japan brought greetings from this Society. Bengt Ranby offered greetings from the Royal Swedish Academy of Sciences and the European Polymer Federation. Both described the major impact that Otto has had on Polymer Science in Japan, Sweden, and in Europe. This session was closed with Nancy Tooney, Chairperson of the local New York Section of the ACS and Professor at the Polytechnic University, extending regards from the local section.

*For a biography of Professor Vogl, see POLYMER NEWS, Volume 17, 343 (1992); see also POLYMER NEWS, Volume 8, 114 (1982). For further discussion of this meeting see *C&E News*, November 30, 1992.

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Plaza Hotel

The technical program began with a talk by Joseph Wirth, Senior Vice President and Chief Technical Officer of Raychem, Palo Alto, USA, who spoke on the "Challenge of High Added Value Materials". Dr. Wirth felt the 50-60's were the growth and discovery periods for engineering polymers and that the creation of new materials which became large volume polymers, slowed considerably in the 70's and 80's.

Through the 90's and beyond, he sees few, if any, new large volume polymers being developed and any new polymers will only shift market share (not increase it). He foresees a significant emphasis on pollution-free, energy efficient polymer processes,

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and specialized performance polymers. For the latter, the key characteristics will include biological polymers, polymers with exceptional electrical and optical properties, highly ordered structures, materials with extremely high strength even at high temperatures and with unlimited chemical resistance. Wirth described one example in which Raychem plays a leading role; a polyacrylate with long, liquid crystalline ester side chains. Wirth concluded that in order to succeed, the polymer industry must invest now (in the 90's) in the technologies of the early 21st century. It must form alliances with both end-users as well as with universities and government laboratories to share the cost of these developments.

Paolo Galli, vice president and corporate research director, Montecatini, Milan, Italy, described the new and exciting breakthroughs at Montecatini in catalyst development and in the processes on which the future products of alpha-olefin polymers

Entrance of Plaza Hotel, New York City

Annamaria Galli Paolo Galli Takeo Saegusa

Gerald Krishenbaum *Eli M. Pearce*

Karl Schloegl (l), Desiree Schweitzer (Press Officer, Austrian Consulate) (c), Frank H. Schiwek (General Consul of Austria, NYC)

will be based. He traced some of the advances in the area of Ziegler-Natta catalysis of the 80's and stressed particularly the new super active catalysts which he called the fourth generation of Ziegler-Natta catalysts. Where the initial work centered on high yields, high productivity and high purity polymers, the new catalyst developments allow the design of specific polymer and copolymer structures by stereospecific polymerization to give directly the final products. This would include the composition of selected copolymers, especially of propylene, designed bulk density and shape of polymer particles — which can now be used immediately for injection molding. He feels these new developments can lead to an entire series of modified polyolefins especially of polypropylene that could readily compete with other engineering resins but have lower density and would be more cost effective. In other areas of polymer science, Galli sees key growth for polymers in biotechnology and medical applications, new specialized materials, new information systems and significant efforts in the areas of energy optimization, resource recovery and waster minimization.

Naoya Yoda, president and CEO of Toray Corporate Business Research, Inc. Chiba, Japan, explained that the polymer industry, especially in Japan, is changing from quantity to quality. He believes that we must have world-wide cooperation, not competition — free trade, not trade barriers and tariffs. He explained that 80% of the chemical industry of Japan has some university collaboration. Japan has succeeded in efficiency in technology because it brings together private industry, academia and government to perform the higher risk, longer-term research, thus sharing costs and rewards. Japanese industry is planning for the future and is willing to change and is in the process of changing. For example, in 1960, Toray was a 100% fiber company (originally a leading spinning company) but by 1990, its businesses were 50% fibers, 23% plastics and the rest a variety of new businesses (electronics, phosphorous chemicals, protein engineering, medicines) and by 2000 he expects Toray's businesses will each have a one third share.

Dieter Freitag, Director of R&D of the Bayer Plastics Group, Leverkusen Germany, discussed his views on the following driving forces for the polymer industry. Key elements will be increased profitability, with strong consideration for the ecology, which means developing processes that have fewer steps, are energy efficient and are environmentally friendly. Freitag gave examples of processes Bayer is developing which include alternate caprolactam and polycarbonate processes. He pointed out that regulations will also play an essential role as a key driving force. For example, in Europe, there is a proposed ban on the use of certain flame retardants as well as on many heavy metals (colorants). Recycling, either reuse of the plastic itself or recovering energy from it, will be another area to which we will have no choice but to commit resources to find solutions. There will also be growth in new technologies and applications such as data storage, blend technology, and the design and construction of automotive body panels.

Manfred Raetzsch, Director of R&D at PCD-Polymere which is part of the Austrian Oil Company OeMV, Linz, Austria, described new polymerization techniques that will be important in the future. He described template polymerizations for symplex formation, charged membranes, radical grafting reactions, controlled polymerization of poly(methyl methacrylate), systems to form IPNs and reactive blending to improve the polymer/polymer interphase.

In the afternoon, the lectures shifted the emphasis from the thrust of future industrial polymer science to academic research and policy development.

Karl Schloegl, University of Vienna, President of the Austrian Chemical Society and General Secretary of the Austrian Academy of Science, Vienna, Austria, brought the greetings of the Austrian Chemical Society and the Austrian Academy of Sciences. Schloegl is the leading scientist in Europe on stereochemistry and conformation of organic and organometallic molecules and the most prolific contributor on optical activity based on the various principles that lead to optical activity. It is no wonder that he was asked to contribute to a symposium for Otto Vogl who plays a leading role in optical activity based on macromolecular asymmetry (helicity).

Professor Schloegl reviewed the important considerations for rotation and restricted rotation and the stereochemistry of organic molecules that lead to optical activity. Of particular emphasis in his talk was the design of optically active metallocenes, their separation

Norbert Bikales, George Bugliarello, President, Polytechnic University Shigeko Suzuki

into enantiomers by column chromatography and their optical stability. Schloegl also pointed specifically to the similarities of specific organic structures to polymers which are more and more becoming the center of attention.

Norbert Bikales, Director of the Polymers Program at the National Science Foundation, Washington, USA, described how the field of polymer chemistry is changing. Polymer Science is a truly interdisciplinary science; while it may have been originally the realm of synthetic chemists, scientists active in polymer science now include engineers, physicists, biologists, bioengineers, and many types of disciplines, including even some aspects of medicine. In 1975, there were only 200-300 faculty members in the US carrying on research on polymers and who were active in teaching some aspects of polymer science. In 1992, this number has increased to 1100. NSF is supporting major new programs in the interdisciplinary field of "Materials Research" which includes polymers.

Kurt Komarek Frank E. Karasz

Kurt Komarek, of Vienna, Austria, the former President of the University of Vienna, the President of the Austrian NSF and member of the Board of the European NSF described the Science Policy, as it exists in Austria and Europe. In Austria, there are no large multinational companies and all universities are national, that is, they are part of the Federal University System. There is a major emphasis to send graduates, as post docs, outside of Austria for some time, to acquire and bring back new scientific knowledge. There is a similar emphasis to attract foreign post docs to come to Austria. Komerak is now working with other European countries as a representative of the European Community for scientific cooperation and through the European Science Foundation.

Richard Stein, University of Massachusetts, Amherst, MA, USA, is deeply involved in the understanding of polymer structure. He traced the history of solution viscosity to molecular weight and the measurement of molecular weight by light scattering. He felt that much detailed knowledge will still be learned as equipment to characterize monomer units continues to be improved and developed. In the not too distant future, we will be able to see not only single

Richard S. Stein Otto Vogl

macromolecules but actually segments of these macromolecules.

Alexander MacLachlan, Senior Vice President of DuPont R&D, Wilmington, DE, USA, described the need in the US for a new academic/industrial partnership. He defined several important industrial trends including increased customer expectations, globalization, efficient manufacturing, environmental issues such as waste minimization, pollution/emission, recycling and new sources of polymers and monomers, especially as petroleum sources are diminishing. He foresees vigorous growth for polymer applications in the transportation industry, housing/construction, clothing, health care, communications and food technology. He emphasized that there must be more industry/academia interaction, and at the same time, ways must be developed to safeguard proprietary information. Academia must maintain its basic focus while also becoming more flexible to the research needs of industry.

Otto Vogl presented his work on the new concepts related to The Rigid Single Polymer Helix. He pointed out that he and his colleagues have recently succeeded in the determination of the

structure of polyhexafluoropropylene (PHFP); the molecule is isotactic and amorphous and, according to solution NMR studies, it is also rigid. Novel calculations of the 20mer allowed the determination of the structure of a 3/1 helix with a 5 degree twist. Similar calculations for polypropylene showed it to be the correct 3/1 helix known for a long time from x-ray data.

Vogl proposed a new concept for stereospecificity and conformational specificity in polymerization. Polypropylene has been synthesized to stereospecific isotactic (or syndiotactic) polymer. It is highly conformationally specific in the crystalline state but essentially a random coil in solution as well as in the melt. The reason for this behavior is that the polymer back-bone of the polypropylene chain is quite flexible. For polypropylene to be a stereoregular polymer, it must be prepared by a stereospecific catalyst system. For polyaldehydes to be stereoregular polymers, they must be prepared under specific conditions, or the side group must be large (4Å). To appreciate the understanding of the stereoregularity of PHFP, the perfluorocarbon backbone is already relatively stiff and the small trifluoromethyl group is sufficient to give PHFP a rigid stereospecific and apparently conformationally specific structure.

The study of the embryonic state of chloral polymerization and the mapping of this genesis has opened a new door, not only for the creation of the single polychloral helix — but also the understanding at what point (chain length and repeat unit) the helical structure begins to develop and when optical activity reaches maximum values. The study of oligomers — and the recognized interest in the embryonic state of polymerization has already spawned a number of research activities in several laboratories in this new area of oligomer research.

Betty MacLachlan *Alexander MacLachlan*

Koichi Hatada, Vice President, Society of Polymer Science, Japan *Otto Vogl*

Koichi Hatada, Osaka University, Toyonaka, Japan, described how to make uniform polymers — uniform in molecular weight, in configuration and/or in conformation. This approach can be used to study polymerization mechanisms as well as solution and solid state properties of polymers. Much of the work employed living polymerization techniques. Some of the polymers studies included poly(meth) acrylates, polyisocyanates and polyaldehydes.

Mark Green, Polytechnic University, Brooklyn, NY, USA, reviewed his recent work on the chirality of liquid crystalline polymers, especially the development of cholesteric phases. He focused on the history of the polyisocyanate structure (Nylon 1) and emphasized the possibility of time dependent liquid crystalline properties of such polymers. Green showed that an optically inactive polymer of the proper structure, when dissolved in an optically active liquid, can develop optical activity. He mentioned the use of cholesteric compounds as guides to induce cholesteric phases in selected helical polymers.

Matthew Tirrell, University of Minnesota, Minneapolis, MN, USA, described his work and interests in tethered chains in polymer microstructures. Tethered chains are macromolecules incorporated into polymer microstructures on one of their ends producing brush-like morphologies. Tethered macromolecules can be produced by chemical grafting or by copolymerization of macromonomers, by star-like structures, or by self-assembly of absorbed copolymers. Such structures are sometimes called polymer brushes. A major end-use area of such polymer structures that shows significant potential is selective adsorption.

The last speaker of the Symposium was Joseph P. Kennedy, University of Akron, Akron, USA, who brought the participants up-to-date on the field of cationic polymerization with some new and exiting ramifications. He described work that is carried out around the world on cationic living polymerization which can now yield reasonably priced, precisely crafted, processible polymers. A number of monomers can now be polymerized by cationic initiators and by cationic living polymerization. This polymerization cannot only be used for the preparation of narrow molecular weight polymers, but can also be used for the preparation of block and random polymers.