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Sixth U.S.-Japan Seminar on Polymer Synthesis: Macromolecular Design for Advanced Materials

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Conference Report

Sixth U.S.–Japan Seminar On Polymer Synthesis: Macromolecular Design For Advanced Materials

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Shiro Kobayashi



Otto Vogl

The 6th U.S.–Japan Seminar entitled “Macromolecular Design for Advanced Materials” was held at the Doubletree Hotel, Santa Rosa, CA, USA from November 6 to November 12, 1993. It was sponsored by the National Science Foundation, USA and the Japan Society for the Promotion of Science.

This seminar is the sixth in a series of regularly scheduled bilateral symposia organized on various aspects of polymer synthesis which have been held over the last 20 years. This series of seminars was initiated by Junji Furukawa and Otto Vogl, who also chaired the first U.S.–Japan Seminar on Polymer Synthesis which was under the topic “Unsolved Problems in Ionic Polymerization.” The first meeting attracted 32 academic and industrial scientists to Hakone, Japan in October of 1974. The second seminar was held in August 1978 in Pingree Park, CO under the co-chairmanship of Joseph P. Kennedy and Takeo Saegusa. The subject of the meeting was “Functional Polymers.” Subsequent seminars in 1983, in 1987 and 1990 were held in Osaka, Japan, in Yountville, CA, USA and in Tokyo, Japan respectively. The Osaka meeting was chaired by Koichiro Hayashi and John Stille and addressed the subject of “Synthesis and Reactions of Oligomers and End-Reactive Polymers.” The 1987 meeting entitled “Synthesis and Reactions of Speciality Polymers” was chaired by Eli M. Pearce and Hidefumi Hirai. The fifth seminar was organized by David A. Tirrell and Eishun

Tsushida in Tokyo and was entitled “Advanced Materials Based on Macromolecules.”

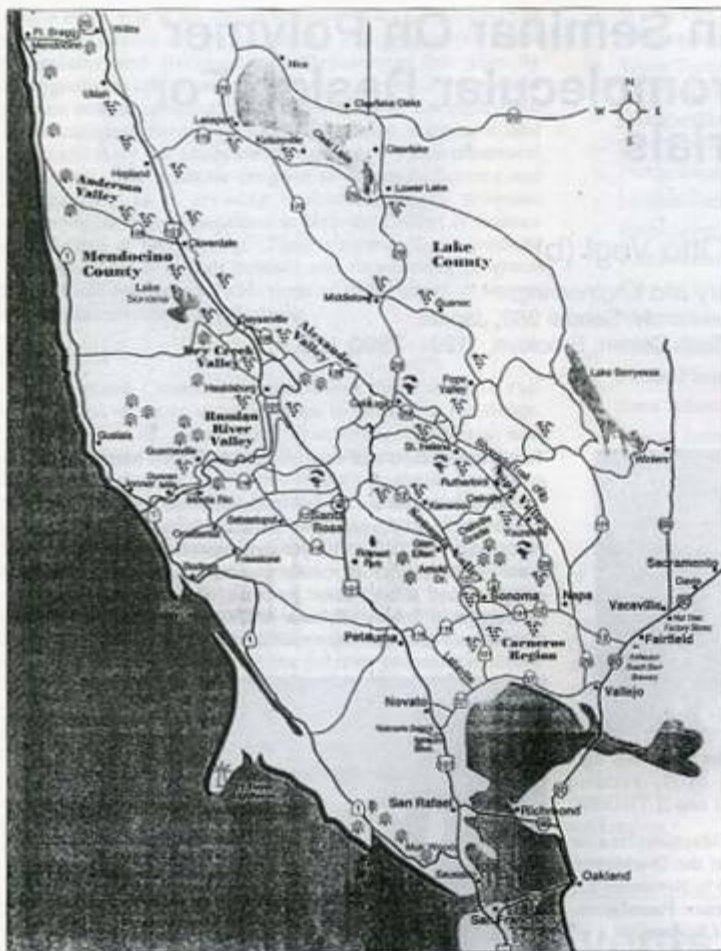
These Seminars are by invitation only and are restricted to a limited number of both active participants and observers from Japan and the U.S.A. The proceedings of each meeting were made available to the scientific community through publication of the original articles based on the lectures in special issues of the *Journal of Polymer Science-Chemistry*. Abstracted forms of the seminars have also been published in *Polymer News*.



Yukio Imanishi

Virgil Percec

This year's U.S.–Japan Seminar on Polymer Synthesis was co-chaired by Professors Yukio Imanishi, Kyoto University, Kyoto, Japan, and Virgil Percec, Case Western Reserve University, Cleveland, OH, US. There were 27 active participants at the meeting, nearly equally divided between Japanese and U.S. scientists and 15 observers. The meeting started on November 6, 1993 with a welcoming reception. Two excursions were held in the afternoons and one banquet was held on November 10, at the Fountaingrove Country Club, which belongs to FUTSU Golf Clubs Co. Ltd., a Japanese company. The meeting was opened on Sunday morning by the co-chairmen



Northern California



Downtown Santa Rosa

of the conference, Virgil Percec and Yukio Imanishi.

The first paper was entitled "Synthesis of Key Monomers for Advanced Polymer Materials Using Cyclodextrin as Catalyst" by Hidefumi Hirai, Science University of Tokyo, Tokyo, Japan. He found that aromatic dicarboxylic acids, which are key monomers for the synthesis of high performance polymers and liquid crystalline compounds such as 4,4'-biphenyldicarboxylic acid, and 2,6-naphthalenedicarboxylic acid, could be synthesized in excellent yields from the monocarboxylic acids, carbon tetrachloride and β -cyclodextrin in the presence of sodium hydroxide and copper. The use of these agents provided the dicarboxylic acids in high yield and in high selectivity; in some cases as pure compounds free of other isomers. α - and γ -cyclodextrin were found to be less effective. It is believed that the carboxylations occur specifically because of the possibility of

inclusion complex formation of three agents within the cyclodextrin tube.

Otto Vogl, Polytechnic University, Brooklyn, NY, presented his work on "Stereoregular Polymerization and Chiral Crystallization." He described first that three general principles have now been identified for the preparation of stereospecific addition polymers (polyolefins or polyaldehydes). Not only can stereospecificity be introduced by the use of stereospecific initiating systems for the proper stereospecific placement of the monomer units such as in the polymerization of α -olefins but steric factors can also influence and determine stereospecificity. Good examples are the polymerization of trihaloacetaldehydes where the bulky trihalomethyl side groups are attached to the flexible polyoxymethylene backbone chains. On

the other hand, the steric and electronic hindrance in the polymer backbone chain in polyhexafluoropropylene play a determining role in the stereospecific propagation to stereoregular (isotactic/helical) polymers even in radical polymerizations. The crystallization behavior of many compounds show a remarkable similarity to polymerization. It was found that the crystallization of sodium chlorate or sodium bromate from concentrated aqueous solutions, forms levo- or dextrorotatory crystals. It was found by proper nucleation with optically pure chiral crystals that the entire crystallization can be directed specifically and the crystallization of levo- or dextrorotatory chiral inorganic salts can be achieved by chiral nucleation.

"Multivalent Ligands for Inducing Receptor-Receptor Interactions" was presented by Yukio Imanishi, Kyoto University, Kyoto, Japan. Peptide hormones convey the



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Shiro Kobayashi

information to cells by binding to the specific receptor, which activates the signal transduction cascade. Signal transduction was found to cascade of the same or different types of receptors which interact with each other to so-called receptor-receptor interactions. The receptor of the multivalent ligand system was dependent on the ligand concentration of the liposome and the length of the spacer group between the peptide hormone and the lipid moieties. Receptor affinity was also dependent on the length of the space between the two peptide moieties.

Eli M. Pearce, Polytechnic University, Brooklyn, NY, presented his work on "Polymer-Polymer Miscibility through Hydrogen Bonding: The Silanol Function". He found that in the study of blends in which the driving force for miscibility is hydrogen-bonding interaction, polymers containing *p*-(hexafluoro-2-hydroxyisopropyl) styrene or 4-vinylphenol functional groups have been very effective. In light of this successful study, the organosilanols have been synthesized and introduced into copolymers. The synthesis and characterization



Doubletree Hotel



Welcoming reception

of silanol groups containing polymers and their blends with poly (*n*-butyl methacrylate) were discussed.

Eishun Tsuchida, Waseda University, Tokyo, Japan, discussed "Simultaneous Multi-Electron Transfer for Poly (Phenylene Sulfide) - Synthesis Through Oxidative Polymerization." One-step multi-electron transfers for poly (phenylene sulfide) synthesis through oxidative polymerization of diphenyldisulfide. One-step multi-electron transfers can profoundly affect the outcome of chemical reaction with Schiff-base compounds of bi-nuclear vanadyl complexes. One-step two-electron transfers could be achieved and oxidative polymerization that was applicable to disulfides and also to aryl sulfides could be oxidatively polymerized to polysulfonium cations which possesses a hyperpolarized structure and ultimately lead to the synthesis of high molecular weight poly (*p*-phenylene sulfide).

"Living Radical Polymerization" was discussed by Krzysztof Matyjaszewski, Carnegie-Mellon University, Pittsburgh, PA. Radical polymerization for a long time has been considered as impossible to realize in a living system, i.e., when effects of chain breaking reactions such as termination or transfer can be neglected. It was concluded that potential living radical systems should be based on the synthesis of relatively short chains at low concentrations of growing radicals, because it is necessary to established equilibria between growing free radicals and dormant species. The author presented the polymerization of vinyl acetate into well defined polymers with molecular weights up to 30,000. The initiating systems were based on various closely related alkylaluminum compounds; block copolymers could also be prepared.

Jean M.J. Fréchet, Cornell University, Ithaca, NY, discussed "Design, Synthesis and Properties of Hyperbranched Dendritic Macromolecules". Linear polymers owe many of their properties to the entangled state, dendritic macromolecules are quite unique in that they do not seem to be entangled to the unusual globular architecture. Several routes to monodispersed dendritic polyethers, polyesters and polyamides were described as well as the preparation of totally novel "surface-block", "layer block", and "segment block" copolymers that have no analogs in the classical linear polymers. Other hybrid linear-hyperbranched structures are obtained by copolymerization of dendritic

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Photo with speakers (from left):

Front row – K. Matyjaszewski, D. A. Tirrell, H. Hirai, V. Percec, Y. Imanishi, O. Vogl, S. Kobayashi, E. Pearce and J. P. Kennedy

Second row – B. Novak, M. Kurihara, T. Masuda, A. E. Feiring, Y. Chujo, L. J. Mathias, R. H. Grubbs and Sawamoto

Top row – T. Kajiyama, K. Kataoka, S. Tokura, H. Ohno, T. M. Swager, J. V. Crivello, C. Pugh and S. MacDonald

macromonomers with ordinary vinyl monomers, by reaction of living anionic polymers with dendritic fragments, or by grafting processes. Hyperbranched polymers are not 100% branched (50–60% is usually the norm). They possess many of the characteristics of the dendritic state, in particular, their solution viscosity remains very low even at very high molecular weights. These polymers are promising for such applications as rheology control agents, additives, coatings and others.

“Side Chain Liquid Crystalline Polymers by Ring Opening Metathesis Polymerization” was discussed by Coleen Pugh, University of Michigan, Ann Arbor, MI. A new class of side chain liquid crystalline polymers was recently synthesized by ring-opening metathesis polymerization of mesogenic norbornene derivatives. The resulting well-defined polymers were used to determine the basic structure-property relationships of both chain terminally attached or laterally attached liquid crystalline polymers based on polymers with norbornene backbone structures. The synthesis of polynorbornene backbones with laterally attached mesogens was also discussed in order to prepare polymers with smectic mesophases.

Mitsuo Sawamoto, Kyoto University, Kyoto, Japan, discussed his work on “Living Cationic Polymerization Towards Molecular Design”. He pointed out that living cationic polymerization allows us to synthesize a variety of precisely controlled polymeric architectures. One of this type of living cationic polymerizations provides synthetic advantages that unlike some other living processes can tolerate polar groups that are attached to the monomers. This permits a variety of functionalities to be

incorporated into specific positions in linear as well as multiarmed (spatially controlled) polymers. The author discussed specifically the precise synthesis of functionalized polymers by living cationic polymerizations of (a) styrene-vinyl ether block polymers and (b) star polymers with new multifunctional terminating agents.

Bruce M. Novak, University of Massachusetts, Amherst, MA, presented his work on “Living Polymerizations Using Well-Defined Transition Metal Complexes: Extended Chain Polycarbodimides”. The author pointed out the central



Excursion in Sonoma Country



Excursion

importance in the design of new living polymerizations as the ability to control the reactivity of the propagating chain ends. Some of his work is focused on the development of living catalysts for the synthesis of well defined secondary polymer structures, such as helical polyisocyanates $[\text{CpTiCl}_2(\text{OR})]$ and polyisocyanides $[\eta^1\text{-C}_2\text{H}_5] \text{NiCF}_3\text{CO}_2$. Recently the author could demonstrate that carbodiimides could also be polymerized by using titanium amidine complexes involving silicon-nitrogen containing complexing agents as catalysts. These titanium complexes were found to be quite active initiators for a number of symmetric and unsymmetric carbodiimides to rigid polymers of very high molecular weight.

"The Synthesis and Cationic Photopolymerization of Novel Monomers" was presented by James V. Crivello, Rensselaer Polytechnic Institute, Troy, NY. Diaryliodonium and triarylsulfonium salts are new classes of latent, highly efficient photoinitiators for cationic polymerization. Their use allows the development of cationic polymerization for many technical applications including, coatings, adhesives, printing inks, and microelectronic photoresists. The author has been interested in the polymerization of aromatic vinyl, 1-propenyl or isopropenyl groups which were activated towards cationic polymerization by

the presence of one or more alkyl ether groups situated on the aromatic ring. In this polymerization normal cationic polymerization is accompanied by ring-closure reactions to give polymers with indane groups along the backbone; such polymers display excellent thermal resistance.

"Novel Organoboron Polymers by Hydroboration Polymerization" were described by Yoshiki Chujo, Kyoto University, Kyoto, Japan. Hydroboration is a well-known tool in organic synthesis, which takes place under mild conditions to produce alkylborane compounds in almost quantitative yield. A novel methodology was developed for the preparation of organoboron polymers by means of hydroboration. The author described the hydroboration polymerization between dienes and thexylborane (the 1:1 addition product of boron hydride to tetramethylethylene). Thexylborane was used as the monoalkylborane component for the polyaddition to nonconjugated dienes. The alkyl groups attached to the boron atoms of the polymers can be replaced by a number of reagents which allow the introduction of various functional groups such as hydroxyl and nitrile groups into the polymers. Chujo also described the synthesis and characteristics of poly(cyclodiborazane)s from dicyano compounds and dialkylboranes. The haloboration polymerization, a polyaddition of diynes with boron tribromide to the poly (organoboron halides) makes available for the first time polymeric Lewis acids.

Andrew E. Feiring, DuPont Company, Wilmington, DE, gave an overview of the "Synthesis and Properties of New Fluoropolymers". Fluoropolymers are among the oldest high



Andrew E. Feiring

Eli M. Pearce



Banquet reception

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performance polymers, dating from the discovery of polytetrafluoroethylene in 1938. They continue to attract much attention due to the unique combination of properties. Important perfluoropolymers, in addition to polytetrafluoroethylene are the melt processable copolymers, other fluorinated plastics, elastomers, lubricants, coatings and, most recently, the amorphous and soluble perfluoroplastics of high glass transition temperature of DuPont and Asahi Glass. The author described the synthesis of fluorinated engineering resins based on the introduction of fluorinated groups into polyamides and polyimides. Some of these polymers have been found to have interesting nonlinear optical properties. Multilayer films have been found to exhibit a high degree of polar orientational order and thermal stability plus good optical quality as revealed by second order generation. An additional, most interesting group of fluoropolymers are fluorinated polyethers with multiple applications as lubricants have recently been prepared by fluorination of partially fluorinated polyethers such as $(CF_2CHFOR)_nCH_2O$ with elemental fluorine.

"Design, Synthesis, and Properties of Substituted Polyacetylenes" was the subject of Toshio Masuda, of Kyoto University, Kyoto, Japan. Group 5 and 6 transition metal catalysts effect the polymerization of various substituted acetylenes to provide high molecular weight polymers up to molecular weights of one million. The author discussed the polymerization of (a) synthesis and properties of poly(diphenylacetylenes) and (b) living polymerization of ortho-substituted phenylacetylenes. Diphenylacetylene was found to polymerize in the presence of tantalum pentachloride/tetra-n-butyltin catalysts to polymers that are insoluble and have an unusually high thermal stability both in oxygen as well as in nitrogen. Substituted phenylacetylene polymerize more readily with a molybdenum based ternary catalyst such as $MoOCl_4 \cdot n-Bu_4Sn \cdot EtOH$ 1:1:1 which provides a living polymerization system with ortho-substituted diphenylacetylenes with large ortho substituents.

"What Can Protein Synthesis Teach Us About Polymer Materials Science?" was the question asked by David A. Tirrell, University of Massachusetts, Amherst, MA. He discussed the design and construction of artificial proteins that form well-defined crystals, films, and surfaces. The design of such materials draws on ideas taken in part from polymer chemistry and physics and part from structural biology, and exploits the sequence control and chain-length uniformity provided by genetic engineering. Four main issues were discussed: i) strategies for efficient and accurate syntheses of wholly artificial proteins; ii) design and fabrication of polymeric crystals of controlled thickness and surface functionality; iii) incorporation of non-natural amino acids; and iv) synthesis of monodispersed, polar, helical rods and the prospects for their assembly into larger-scale structures. He discussed the synthesis strategies, the design synthesis of macromolecular crystals, incorporation of non-natural amino acids and the mono-dispersed helical rods, namely, poly (α -glutamic acid).

"Selective Sulfation of Chitin Derivatives for Biomedical Functions" was the subject of Seiichi Tokura, Hokkaido University, Sapporo, Japan. Chitin, a natural abundant mucopolysaccharide, is known to be β -1,4-glycan of N-acetyl-D-glucosamine. It is present in all shellfish and insects and is the structural element of lower animals as cellulose is for plants;

chitin is also known to be biodegradable and has low toxicity. The sulfated derivative of chitin although similar in structure to heparin was found to have relatively little anticoagulant activity on the blood clotting but it showed very significant anti-cancer activity for specific melanomas.

"Molecular Recognition Directed Self-Assembly of Supramolecular Architectures" was the subject of Virgil Percec, Case Western Reserve University, Cleveland, OH. Supramolecular chemistry is the chemistry beyond the molecule, namely, the designed chemistry of the noncovalent binding interactions, just as molecular chemistry is the chemistry of the covalent bond. Molecular recognition, preorganization and self-organization form the basis of spontaneous generation of self-assembled architectures from their components under a well-defined set of conditions. Endo and exo-recognition processes are responsible for the self-assembly and stabilization of transition states in enzymatic reaction for the generation, self-replication and self-assembly of natural supramolecular architecture. Specific examples that were discussed involved the design of Tobacco Mosaic Virus-like supramolecular synthetic system exhibiting various mesophases of thermotropic cyclophanes and of willow-like dendrimers.



Otto Vogl

David A. Tirrell

Kazunori Kataoka, Science University of Tokyo, Noda, Japan, discussed "Block Copolymer Micelles as Vehicles for Drug Targeting". Nanoscopic vehicles with microcontainer separating from the outer environment are promising for site-specific delivery of drugs as well as of external genes. Promising results have been reported for the use of natural vehicles, i.e., virus and lipoproteins for this purpose; yet the tailoring process is rather complex and the choice of substances that can be incorporated is rather restricted. The author has focused on the block copolymer micelles as drug vehicles because they have relevant properties. He has succeeded in developing stable multimolecular micelle systems with a drug-binding inner core, having excellent utility as the vehicle as a targeting therapy for solid tumors. The micelle-forming polymeric drug, Adriamycin-conjugated poly (ethylene oxide)-poly (aspartic acid) block copolymer was prepared by conjugating adriamycin [a potent

hydrophobic anti-cancer drug] to the pendent carboxyl groups of the copolymer. Micelle formation immediately occurred. A block copolymer of poly (ethylene oxide) and poly (β -L-aspartate) when exposed to adriamycin also incorporates the drug into the central hydrophobic portion of the micelles. Very impressive data on tumor selectivity of these micelles which carry both of these drugs conjugates of adriamycin selectively to the extravascular tumor targets were presented.

Joseph P. Kennedy, University of Akron, Akron, OH, presented his new work on "New Designed Biomaterials by Cationic Polymerization". Living carbocationic polymerization of olefins has led to a great variety of well-defined new materials, including narrow molecular weight distribution polyisobutylene, new thermoplastic elastomers, telechelic prepolymers, and novel macromonomers. New synthesis of designed polymeric biomaterials, for example, of polyisobutylenes carrying one, two or three (three arm star molecules) cyanoacrylate end groups, which were designed for use as synthetic intervertebral discs, have been made. The author specifically discussed the synthesis, characterization and biomedical testing of amphiphilic networks prepared by solution copolymerization of methacrylate-telechelic polyisobutylenes and water-soluble methacrylates, for example, 2-hydroxyethyl methacrylate. These amphiphilic networks swell both in hydrocarbon solvents and in water.

"Molecular and Morphological Designs of High Performance Polymeric Membranes" was presented by Masaru Kurihara, Toray Industries Inc., Otsu, Japan. Reverse osmosis and ultrafiltration play an important role in industrial separation technology. To develop high performance polymeric membranes, it was essential to design molecular structures and polymer morphology of the membranes for their specific application. The new reverse osmosis membranes are based on aromatic polyamides of a combination of two and three aromatic carboxylic acid and three or two aromatic amine functionalities. The membranes were laid down as thin films by interfacial polymerization on a polysulfone support. Not only does this technique provide the thin polymer membrane structure that is needed, but it also provides the unusual surface characteristics of amino and/or carboxylic acids functionalities. It was possible to prepare membranes with 99.5% salt rejection for water containing 1500 ppm. It was claimed that some of such membranes also function efficiently at up to 98% rejection for salt solutions that have salt concentration similar to that of seawater. In ultrafiltration, several aromatic polysulfone membranes have been made based on technology that develops the aromatic polysulfone structure in the last stage.

Robert H. Grubbs, California Institute of Technology, Pasadena, CA discussed "Ring Opening Metathesis Polymerization Catalysts". He concluded that a number of new catalysts for the ring opening metathesis polymerization of cyclic olefins have been developed, including molybdenum, tungsten and ruthenium complex catalysts substituted with aromatic amines, phosphines and even partially fluorinated alkyl groups. These metathesis catalysts were used for the ring-opening polymerization with a number of interesting cycloolefin monomers with various functionalities.

Shiro Kobayashi, Tohoku University, Sendai, Japan, presented his work on "Germylenes as Monomers for Polymer Synthesis". Germylenes are divalent germanium species having



Planning for the next U.S.-Japan Seminar, past and upcoming Chairmen

strong reducing power. Recently such germylenes have been utilized as reactive monomers for the synthesis of germanium-containing polymers. The following reactions were carried out: (a) Alternating copolymerization with *p*-benzoquinone derivatives; (b) 2:1 Periodic copolymerization with *p*-benzoquinone derivatives; (c) Alternating copolymerization with cyclic α , β -unsaturated ketones; (d) Copolymerization with acetylene monomers; (e) Ligand substitution polymerization to polygermanes. The germylenes in the alternating copolymerization are very reactive reductive monomers in combination of *p*-benzoquinone derivatives as the oxidant monomers. They reacted even at -78°C within one hour without a catalyst and gave alternating copolymers with high molecular weight in essentially quantitative yield. This reaction has been proven to be a biradical mechanism.

Scott MacDonald, IBM Almaden Research Center, San Jose, CA, discussed "Photogenerated Base in the Design of Resist Materials". Numerous examples of organic imaging systems derived their high sensitivity from photoinitiation of free radical chain reactions. During the last few years, a number of very sensitive resist systems have been reported that function on the basis of photogenerated acids. In these systems, a neutral substance is incorporated which undergoes photolysis to produce strong acid as one of the photoproducts. The latent image of the acid that is generated upon exposure is exploited as a catalysts for a subsequent thermolysis or cross-linking reaction that causes the change in the solubility of the host polymer. There are several neutral substances that are known to undergo photolysis with relatively high quantum yields to provide basic photoproducts. This makes it possible to design new imaging systems that utilize "photo-base" generators in a manner analogous to the acid catalyzed system. The latent image of photogenerated base has been used to catalyze decarboxylation of appropriately functionalized polymers bearing pendent carboxylic acid groups. Examples of neutral molecules that generate amines upon photolysis include cobalt amine complexes and carbamates of benzyl alcohols. Examples of functionalized polymers that undergo base catalyzed decarboxylation include 4-vinylphenylacetic acids substituted with appropriate electron withdrawing substituents.

Tisato Kajiyama of Kyushu University, Fukuoka, Japan, discussed his work on "Interfacial Interaction of Polymer-Liquid

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Crystalline Molecules and Electro Optical Properties of Composite Systems". A (polymer/liquid crystal: LC) composite film, in which LC molecules are embedded in a three-dimensional polymer matrix, shows reversible light scattering - light transmission switching upon off- and on- a.c. electric fields. The electro-optical response of LC molecules was found to be strongly influenced by the anchoring strength of the LC molecules on the polymer walls. When a higher magnitude of electric field than the threshold value was applied to the glass sandwiched LC cell in which LC molecules align homogeneously, the dipole polarization of the LC molecules increased non-linearly by the orientation of the LC molecules along the direction of an applied electric field. Then the response wave charges for the applied fundamental wave was deformed.



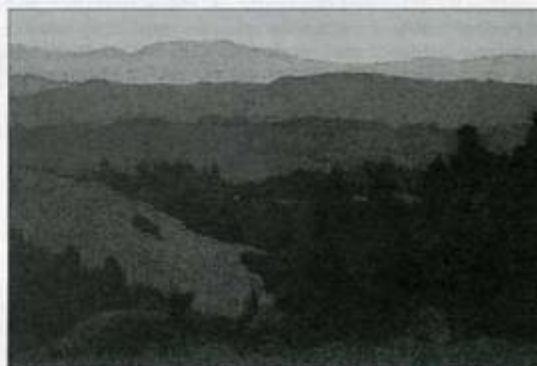
Sonoma Coast

Lon J. Mathias, of the University of Southern Mississippi, Hattiesburg, MS, described the "Synthesis and Cyclopolymerization of Derivatives of α - (Hydroxymethyl) Acrylates: Facile Synthesis of High Molecular Weight Copolymers". Radical cyclopolymerization of some α - (hydroxymethyl) acrylate ether dimers give novel cyclopolymer with tetrahydropyran units in the polymer backbone. The cyclopolymerization was performed in bulk or in organic solvents. In most cases the polymerization proceeds spontaneously without added initiator. Bulky tertiary alkyl esters showed high cyclization efficiency.

"Polymer Solvents for Electrochemical Reactions" was presented by Hiroyuki Ohno, Tokyo University of Agriculture and Technology, Koganei, Tokyo, Japan. Electrochemical reactions are based on the following two requirements: a) Electron transfer from electrode to substrate and b) Counter-ion migration to compensate the charge change. When these points are satisfied, it should be possible to carry out electrochemical

reactions even on polymers. A group of synthetic polymers called "ion conductive polymers" have reached considerable interest for this application. Poly(ethylene oxide) dissolves considerable amounts of salts and can be considered a polymerized system. The advantage of the use of polymer/solvents are as follows: wide, potential window, excellent salt solubility, wide temperature range, light weight easy to handle, cheap, stable. On the other hand, relatively high resistance is still a big disadvantage for polymeric systems.

Timothy M. Swager, University of Pennsylvania, Philadelphia, PA, discussed "Metal Catalyzed Cross-Coupling Reactions in the Synthesis of New Conducting Polymers". Metal-catalyzed coupling reactions are powerful tools for step-reaction polymerizations leading to highly unsaturated polymers with complex functionality. A number of systems were discussed to demonstrate how the reactions could be used to generate conducting polymers, primarily, sensory polymers, as well as precursors routes to graphite ribbons.



"Vision Sonoma"

The 6th U.S.-Japan Seminar on Polymer Synthesis was found to be extremely successful. Some participants have claimed that it was the most successful seminar of the series. It was not only a superb example for this kind of meetings, it was also most productive from the scientific point and from the general meeting point of view; the meeting was well organized and conducted. As in the past, the objective of these five to six days that scientists from Japan and from the U.S. interested in polymer synthesis spent together, was not only to exchange scientific information, but also to get to know each other better, to enhance established friendships and to create new ones. A considerable change in the persons that participated was noticed in the last two meetings. There was a smooth transfer of the scientific impact of the meeting from the well established scientists to a new generation of scientists with new and advanced ideas. This progress promises a bright future for polymer science and technology, especially for polymer synthesis in the two participating countries, the U.S. and Japan.

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