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Polymer Science at the Kyoto Institute of Technology, Kyoto, Japan

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Polymer Science in Kyoto, Japan: Kyoto Institute of Technology



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Kyoto is one of the major centers for polymer science research and education in Japan. Some 10 years ago, a detailed account of the activities in polymer science at Kyoto University was written by Professor Akio Nakajima of Kyoto University and published in *Polymer News*. In the last two decades polymer science has also rapidly developed at the Kyoto Institute of Technology (KIT). Today we will describe KIT and the activities that are now carried out there in research and education in polymer science.

KIT was founded in 1949 as a national university incorporating two national colleges: Kyoto College of Industry and Kyoto College of Textile Fibers, which were established in 1902 and 1899, respectively.

KIT is located in the northern part of Kyoto City, which was, for more than 1000 years, from 794 to 1868, the capital of Japan. Kyoto is surrounded by mountains on three sides and offers many scenic sites, including over 250 shrines and some 1500 temples with beautiful gardens which the cultural and spiritual atmosphere of Kyoto.

KIT consists of the Faculty of Engineering and Design and the Faculty of Textile Science; it offers programs of 4-year education leading to a Bachelor's degree. In 1988 KIT introduced important innovations with respect to the following three phases:

- (1) Broad recognition of the undergraduate program. The undergraduate program was reorganized in the form of four departments in the Faculty of Engineering and Design and two departments in the Faculty of Textile Science. Furthermore, the new programs in all six departments are now offered separately in the evening.
- (2) Establishment of a doctoral program. The graduate program was extended to include courses leading to a Master's degree and to a Ph. D. The major objective of this change was to serve the needs of students and persons who desire a broader and deeper acquaintance with the ideas and methods of higher modern scholarship and research in the fields of science and technology.
- (3) Discontinuance of the Technical College. The Technical College decided to end its educational activities after 37 years and the staff members were integrated into the Faculty of Engineering and Design.

Accompanying these innovations, KIT was reorganized in 1988 into the following departments: Mechanics and Systems Engineering; Electronics and Information Science; Chemistry and Materials Technology; Architecture and Design; Applied Biology; Polymer Science; and Engineering.

In the graduate school, which was established in October 1988, a Master's degree program became available in Mechanical System Engineering, Electronics and Information Science, Chemistry and Materials Technology, Architecture and Design, Applied Biology, Polymer Science and Engineering. A doctoral program became available in Applied Science for Functionality, Material Science, Information and Production Science, Chemistry and Materials Technology, Architecture and Design, Applied Biology and Polymer Science and Engineering.

The University is headed by its president, Professor Tomomasa Tatsumi, assisted by the Dean of Engineering and Design, Professor Yurii Ikeda and the Dean of Textile Science, Professor Takeo Araki.



Shinzo Kohjiya and Takeo Araki



Otto Vogl

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KIT has 106 professors, 97 associate professors, 16 lecturers, 54 instructors and a total number of 450 employees.

Polymer Science is taught in two departments, the Department of Chemistry and Materials Technology, and the Department of Polymer Science and Engineering. The Department of Chemistry and Materials Technology has a Division of Functions of Materials which gives Master's degrees in functional polymeric materials and in function of biopolymers. In the Division of Properties and Processing of Materials, the opportunities for advanced degrees are in technology of high temperature processing, in the physical chemistry of polymeric materials and in the processing of organic materials.

The Department of Polymer Science and Engineering consists of two divisions: Polymer Chemistry and Material Science of Polymers. Material Science of Polymers includes molecular design of polymers, functional materials, material science, fiber materials, theory of polymer solutions, biochemistry of materials, structural chemistry of polymers and polymer physics. The Department of Polymer Science and Engineering has programs in functional chemical engineering, material science, polymer mechanics, polymer processing, molecular engineering of polymers, textile engineering and systems engineering.



Kiyomizu Temple, Kyoto

Molecular design of high polymers and applied polymers are also available in the Division of Science of Molecular Design. Other subjects that are available include design and processing of polymeric materials, photoresponsive materials and various aspects of separation science.

In polymer science and in polymer chemistry, Master's degrees are available in polymer synthesis, biopolymer chemistry, molecular design of polymers, polymer physics, physical chemistry of polymeric systems, spectroscopy of polymers, molecular engineering of polymers, fabrication of polymers and analytical chemistry. In polymer engineering there are opportunities for Masters' degrees in textile engineering, polymer reactions, synthesis of biomolecules, polymer structure, chemistry of polymeric materials and physical aspects of biopolymers.

Biological macromolecular sciences as well as functionality of polymers are available in Ph. D. programs in the Division of Applied Science for Functionality which includes biological macromolecular science, molecular and structural design for polymers, polymer functionalizations, polymer morphology, control



KIT Campus

of functionality for polymers as well as photo- and electronic processes of polymers.

About 30 Master's degrees are given in polymer science every year and almost 20 Ph. D.s are graduated at the KIT at the same time period.

Let us emphasize again that the KIT is a National University established under the National School Establishment Law of 1949. It is composed of two faculties in the Graduate School with their own administrative systems. Admission to the freshman class of KIT takes place in April of each year and is limited to those applicants who, by the annual entrance examinations, are best qualified to benefit from the educational opportunities which KIT can offer.

The size of the entering class is limited for the Faculty of Engineering and Design to 565 students, including 100 Evening Program students and to 215 students for the Faculty of Textile Science, including 40 Evening Program students.

The decision of the faculty with respect to admission is based on the following factors: (1) Results of nationwide examinations by the National Center for University Entrance Examinations (held in January); (2) The KIT Entrance Examination score (held in March); (3) Senior high school records and grades.

The undergraduate school of KIT has nearly 3000 students. The graduate school has over 200 students, including 45 students registered in the Department of Polymer Science and Engineering for the first year and 15 in Applied Science and Functionality.

The Faculty of Engineering and Design at KIT has grown with the rapid development of modern science and technology in Japan. It was founded in 1902 as Kyoto College of Industry to carry out instruction and research toward modernization and the development of the traditional industries in Kyoto. Originally the faculty was structured into three departments: Architecture, Industrial Design and Dyeing. Since its founding, some 3500 students have graduated, trained under specialized technical education with emphasis on the arts. These students have contributed widely to academic, governmental and industrial activities in Japan.

In 1949, KIT began its history as a national university in accordance with the National School Establishment Law, incorporating the College of Industry with Kyoto College of Textile Fibers. The two Colleges became, respectively, the Faculty of Engineering and Design and the Faculty of Textile Science.

The rapid development of Japan's industry from the 1950's through the 1970's brought increasing demands for engineers and researchers in newly developed interdisciplinary areas as well as in the existing fields. In order to respond to these demands, several departments were added at KIT: Design (1954), Mechanical and Production Engineering (1961), Electrical Engineering (1963), Industrial Chemistry (1967), Electronics (1972) and Housing and Environmental Design (1974). The Departments of Weaving Machinery and Ceramic Technology were renamed Departments of Mechanical Engineering (1968) and Inorganic Materials (1970), respectively. In 1988, the undergraduate program was reorganized by grouping the 10 departments into four: Mechanical and System



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Engineering; Electronics and Information Science; Chemistry and Materials Technology; and Architecture and Design. This reorganization enabled wider education and research, and enhanced interdisciplinary studies needed by professionals in the industries of new eras.

Seven hundred eighty undergraduate students (including evening programs) are admitted each year. To KIT, the faculty lays emphasis on instruction in a wide range of science and technology, essential to a variety of careers, and on active research in basic sciences in order to fulfill the needs of society. The 21st century is expected to be characterized by unprecedented high technology and will be an age of many engineering devices. Engineering will be even more needed as a service to society.

Major advances were made at KIT under the presidency of Kenichi Fukui who received the Noble prize in Chemistry in 1981, the first Nobel Laureate in Chemistry of Japan.

In the Department of Chemistry and Materials Technology there is a Division of Function of Materials. This division provides the necessary background for understanding fundamental aspects of chemistry, such as efficient and selective preparation of functional materials, catalytic and photochemical transformations of materials.

One of the professors involved in polymer chemistry is Nariyoshi Kawabata, whose main interests are in polymeric materials that capture microorganisms alive, new materials useful for water purification and new methods for microbiology and biotechnology. Professor Masaaki Teramoto is also involved in membrane separation processes, mass transfer with chemical reactions and reaction kinetics of heterogeneous reaction systems. Yoshikazu Miyake, an Associate Professor in Chemical Engineering, is studying molecular assembly, the development of functional polymer membranes and reactions in two-phase systems.

Shinzo Yamashita is Professor Emeritus of KIT. His main interests were the synthesis and properties of elastomeric ionenes, synthesis, characterization and chemical modification of 1-chlorobutadiene copolymers, rubber chemistry of processing, reinforcement and vulcanization. His work is now being continued



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and expanded by Shinzo Kohjiya, who is most interested in the functionalization of silicone elastomers for electronics applications, sol-gel transition phenomena, functionalization of gels and specialty polymers for biomedical applications. Yuko Ikeda, an instructor in Professor Kohjiya's "koza," is interested in synthesis and properties of biomedical polyurethanes and in the synthesis of polysaccharide derivatives. Kohjiya's group has recently been reinforced by the addition of Associate Professor Yasuhisa Tsukahara, who is working on the synthesis of macromonomers by anionic polymerization, followed by radical polymerization and copolymerization of the macromonomers. He is also investigating the properties of polymacromonomers. Saburo Hara and Kaeko Kamei are biochemists who are studying the structure and function of proteins.

Yoshio Wada is studying the polymer photophysics and photochemistry, particularly the laser photolysis, of organic and polymer molecules, and the laser surface treatment of polymeric materials, as well as photochemical reactions of aromatic amines and alkyl halides.

In the Division of Properties and Processing of Materials, Professor Taisuke Ito is interested in polymer structures, transport properties of dyes and macromolecules such as diffusion of the aliphatic chain molecule in polyethylene, solvent effects on the diffusion of aromatic compounds in polymers and pressure effects on the gelation of macromolecules. Although Tomiji Wakida is primarily involved in textile and polymer processing and in the application of electrical discharge in textile finishing, more important is his work on surface modification of polymer films by low temperature plasma and sputtering.

Kanji Kajiwara is conducting research in polymer physics, gel structure and kinetics of gel-sol transition of biopolymers, the molecular dynamics of model peptides, the quaternary structure of model peptides and its physiological function. Toshihiko Nishida is involved in ceramic engineering, the fracture mechanics of brittle materials, advanced materials and ceramic composites. Lecturer Hiroshi Urakawa is working on the physical chemistry of polymers, the aggregation of dye molecules and its effect on dyeing characteristics, micellar structure of non-ionic surfactants, and on the molecular dynamics of model peptides.



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Faculty of Engineering and Design

A number of professors are involved in the study of polymer chemistry in the Department of Polymer Science and Engineering. The department was established in 1983 with the merging of the two former departments of Textile Engineering and Fiber Chemistry. The department was further reorganized by the inclusion of Applied Mathematics and Analytical Chemistry when the Doctoral program was established in 1988. The new department consists of two integrated divisions. Polymer Chemistry and Polymer Engineering offers students four major programs: Polymer Chemistry, Industrial Biochemistry, Polymer Materials and Polymer Engineering. Each year 125 undergraduates are admitted to the department, and after one year of basic instruction, each student chooses a major. In the final year, students are obligated to undertake research in one of the laboratories in order to graduate. The research and instruction in this division cover the following fields: synthetic organic chemistry, polymer reaction chemistry, biopolymer chemistry, applied polymer science, molecular design of polymers, and analytical chemistry.

Takeo Araki, now the dean of the school, is a professor of polymer chemistry. His interests lie in the functionalization of oligomers, polymer synthesis in general and in separation chemistry, including chromatography.

Toshio Kitao is working in Applied Polymer Chemistry, biodegradable polymers, synthesis, characterization, and medical applications; also of major interest are ceramic fibers from polymeric precursors and high tenacity polymer blends comprising liquid crystalline polyesters as the basic component. Tsuyoshi



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Kiyotsukuri is professor of polymer and fiber chemistry. He is working on molecular design and characterization of functional polymers and fibers, on the development and application of network polymers, on crosslinked polymers and on the functionalization of polyesters and polyamides.

Other professors are working in synthetic organic chemistry, organometallic chemistry, analytical chemistry, biopolymer chemistry and biopolymer biophysics, and analytical biochemistry. Yoshiharu Kimura is a specialist in synthetic polymer chemistry and biomaterials, which includes the synthesis and biomedical application of biodegradable and bioresorbable polymers, the synthesis of inorganic polymers and their utilization for processing ceramic fibers, and in the development of novel polyimide-based materials.

Several associate and assistant professors are also part of the research groups. They include Kiyochi Matsumoto in polymer chemistry, who is working on structure, properties and processing of polymers, biaxial stretching and orientation control of polymer films, the development and application of functional fibers and films and the processing of textile fibers and polymers. Hiroshi Narita is involved in polymer synthesis, especially in vinyl polymerization in the presence of metal salts and in polymer reactions.

Of the instructors, Ken Hosoya is studying molecular recognition using HPLC and asymmetric synthesis using a polymer matrix. Naoto Tsutsumi is studying the analysis of polymer solids by flash radiometry, electrical and optical studies of ferroelectric polymers, polymer synthesis by electro-oxidation and condensation. Applied polymer science is also the subject of Hideki Yamane, who is working on hollow fibers with asymmetric structure, molding and processing, high performance polymer gels, chemical modifications, characterizations and electroconductive ceramic fibers from polymeric precursors.

Chemical engineering and processing is also an important subject at KIT; for example, Susumu Kase is studying the rheology and hydrodynamics of the extension of filament extrusion and films. Zenichiro Maekawa is investigating the mechanical behavior of polymeric composites, the design of polymeric composites and the processing of polymeric composites.

Shunji Nomura's interest is in material science of polymers. He is involved in the study of rheo-optical studies of polymeric

materials, the development of polymers with ultimate properties by structural control and the development of high-strength and high-modulus fibers. Associate Professor Hiroyuki Hamada is studying polymer mechanics, the mechanical properties of composite materials and composite manufacturing.

Photophysical and photoconductive properties of aromatic vinyl polymers are being investigated by Akira Itaya. He is studying the time-resolved total internal fluorescence spectroscopy for dynamic studies on polymer surfaces, the fluorescence dynamics of aromatic vinyl polymer films undoped and doped with electron acceptors and donors and the *in-situ* fluorescence spectroscopy of vacuum-deposition mechanisms of organic compounds. Physical properties of polymers, especially the structure and properties of polymer alloys, the development of high performance polymeric materials and the theory of small elastic scattering are being investigated by Mitsuhiro Shibayama. Okimichi Yano is studying the properties of polymeric solids by investigating the relaxational behavior of polymers at cryogenic temperatures, the dielectric and piezoelectric properties and the nonlinear properties of polymers.

Polymer processing, the rheology of polymeric flow, the permeability of geotextiles, and air jet spinning are the subjects of Taro Nishimura's studies. Qui Tran-Cong is involved in the investigation of the physical properties of polymers, photophysics and photochemistry of polymers, especially the light-induced ordering phenomena in polymer mixtures, the relaxation phenomena in glassy polymers by diffusion-controlled kinetics and the diffusional processes in polymers by forced Rayleigh scattering.

In the Division of Polymer Engineering, there are also several professors involved in polymer process engineering but particularly in systems engineering. Of importance is the work of Shigeru Kunugi, who is studying the mechanism of enzymology, kinetics and mechanisms of proteases, as well as the physical chemistry of membrane mimetics and enzyme reactions under high pressure.

Polymer science and technology is now flourishing at KIT. The activities implement excellently the activities in polymer science at Kyoto University and at the Institute of Chemical Research in Uji which is attached to Kyoto University. The activities in polymer science at Kyoto University and Uji will be discussed in a separate article.