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# Centers of Polymer Research

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## POLYMER SCIENCE IN TOKYO, JAPAN PART 1. CENTRAL AREA<sup>(a)</sup>

By

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Tokyo, the world's largest city with a population of over eleven million, is not only the political and economical center of Japan, but is a very important center of modern industry, culture and sciences. In the metropolitan area, there are about 100 universities and almost the same number of colleges; nearly a quarter of all universities and colleges of Japan. Because the Tokyo area is so extensive, discussions of the academic activities of polymer research in Tokyo will be divided into two parts. This first part will describe polymer research activities of the institutes located in the central area, bordered by the Yamate Line. The second part, which will appear in a subsequent issue, will describe the institutions located in the surrounding areas and suburbs of Tokyo.

The University of Tokyo, the oldest and largest national university, has been the leader in many fields of academic activity in Japan, ever since its establishment in 1877. Today the university consists of ten faculties: Law, Economics, Literature, Education, Science, Engineering, Agriculture, Medicine, Pharmacy, and General Education. In addition, it has more than 20 research institutes, e.g., Institutes of Nuclear and Earthquake Studies and about 10 facilities shared with other institutions, i.e., a Computer Center and an Environmental Science Center. Nine faculties are located on the campus at Hongo, about 5 km north of the Imperial Palace in Tokyo; the College of General Education (attended by students for the first two years) is located at a separate campus at Komaba,

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(a) This article was written in cooperation with Otto Vogl, Polymer Science and Engineering Department, University of Massachusetts, Amherst, Massachusetts, when he was the recipient of the Senior Scientist Award of the Japan Society for the Promotion of Science and Visiting Professor at Kyoto University, Kyoto, Japan.

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a small town on the west side of central Tokyo. The Faculty of Engineering is the largest faculty of the University of Tokyo; it has about 2,000 undergraduate and 1,300 graduate students, 150 professors, 150 associate and assistant professors, and 300 permanently employed instructors. Polymer research at Tokyo University is primarily carried out in two of the 20 departments of the Faculty of Engineering, the Departments of Industrial Chemistry and Synthetic Chemistry. The laboratories directed by Professor Teiji Tsuruta and Shohei Inoue, Hidefumi Hirai, Kei Matsuzaki, and Masaki Hasegawa have research activities with primary objectives in polymer science.



University of Tokyo, Hongo Campus

Professor Tsuruta of the Department of Synthetic Chemistry has for many years been interested in the study of reactivity of monomers, novel polymerization catalysts and in the stereoregularity of vinyl polymers and polyethers. His early work included the revision of Q-e scheme, elementary reactions between organometallic compounds and polar vinyl monomers in relation to their anionic polymerization, and ring opening polymerization of oxiranes by zinc alkyl catalysts. The first success of using carbon dioxide as a comonomer was achieved in Prof. Tsuruta's laboratory. With Instructor Dr. Michihiro Ishimori, a molecular level elucidation of an enantiomeric catalyst used for the stereospecific polymerization of methyloxirane by the crystallographic analysis of chiral structure of the zinc-alkoxy catalyst has been carried out. Another recent achievement in his group is the synthesis of novel polymers with pendant amino groups. Polyion complexes prepared from these polyamines have useful properties as biomedical materials. Prof. Tsuruta's interests have now turned towards medical application of tailor-made polymers and functionalized polymers. This year Prof. Tsuruta retired from the University of Tokyo and moved to the Science University of Tokyo where he assumed teaching and research responsibilities.

Professor Inoue has been independent for the last 2 years but was also jointly supervising Professor Tsuruta's laboratory. He has organized a research group responsible for the development of asymmetric polymerization of oxiranes and  $\alpha$ -amino acid N-carboxy anhydrides. He is also interested in biomimetic polymer chemistry, including carbon dioxide fixation and macromolecular catalysts. Associate Professor Tsuneo Hirano is mainly working on the conformational analysis of polyethers.

The group of Professor Hirai at the Department of Industrial Chemistry has two main research projects; one is concerned with the alternating copolymerization of polar vinyl monomers with electron donating monomers in the presence of Lewis acids and the other with the hydrogenation of dienes using supported noble metal catalysts. The role of molecular complexes as monomers in the alternating copolymerization has been clarified from physicochemical studies. Present targets of research include the sequence control in radical copolymerization, theoretical analysis of NMR spectra of copolymers studied with Assistant Professor Koinuma, and the highly active and selective polymer catalysts being developed in cooperation with Associate Professor Naoki Toshima.

Professor Matsuzaki has been investigating the microstructure of polymers, especially the tacticity of polymers by means of  $^1\text{H}$  and  $^{13}\text{C}$  NMR spectroscopy. Associate Professor Toshiyuki Uryu has been concentrating on polysaccharides syntheses by the ring opening polymerization of anhydrosugars.

Professor Hasegawa, who had formerly been working in the Government Research Institute for Polymers and Textiles in Yokohama, has recently joined the Department of Synthetic Chemistry of the University. He had shown that 2,5-distyrylpyrazine crystals could be polymerized in solid state by sunlight. Since then, his group has found many analogous conjugated diolefins that are polymerizable by photopolymerization under crystalline-lattice control. Associate Professor Fujio Toda's interests are focused on problems in a boundary area between polymer science and biology.



Faculty of Engineering, Hall 5,  
Applied Chemistry Departments

About 20 staff members and 50 graduate students are involved in various research projects of polymer science in the two departments at the University of Tokyo.

In the Applied Physics Department, there are two groups working in the field of polymer physics. Physical properties of synthetic and biopolymers, such as viscoelasticity, piezoelectricity, and conductivity, are being studied by the group of Professor Yasaku Wada with Assistant Professor Reinosuke Hayakawa. Crystal structures are analyzed by small angle x-ray scattering by Associate Professor Koji Okano who is collaborating with Professor Eiichi Wada of Nihon University.

Professor Yoneho Tabata and Associate Professor Kenkichi Ishigure in the Department of Nuclear Engineering are interested in the application of radiation chemistry to polymer synthesis and modification, such as radiation polymerization of unsaturated fluorocarbons and preparation of microporous membranes by neutron irradiation.

Polymer research in other departments of the University of Tokyo may be summarized as follows. Raman and IR spectroscopy of synthetic polymers and poly(amino acids) are being studied by the groups of Professor Mitsuo Tasumi in the Department of Chemistry and of Professor Tatsuo Miyazawa in the Department of Biochemistry, Faculty of Sciences. Biochemical aspects of enzymes and synthetic analogues are the primary interest of Professor Kazutomo Imahori in the Faculty of Medicine. Professor Kazuhiko Atsumi and his group are developing various devices for biomedical application of synthetic polymers. Animals that are implanted with artificial hearts prepared by his group are showing one of the highest survival rates. Dr. Hiroshi Matsumoto, the developer of artificial blood vessels made of Gore Tex (expanded polytetrafluoroethylene), is also working in the Faculty of Medicine. Physical and electric characteristics of polymer solutions are studied by Professor Ichizen Ogino and Koshiro Yoshioka in the College of General Education.

Dynamics and reactivity of synthetic polymers studied by using photochemical techniques are the main concerns of the group of Professor Itaru Mita and Dr. Kazuyuki Horie in the Institute of Space and Aeronautical Science. Professor Hirotarō Kambe in the same Institute is interested in heat resistant aromatic polymers, especially in their structures and solid state properties. In the Institute of Industrial Science, the structural elucidation and modification of natural lacquers of the urushiol type and polysaccharides are studied in Professor Ju Kumanotani's laboratory. Functional membranes for separation methods (ultrafiltration, reverse osmosis) are investigated in Professor Shoji Kimura's and synthetic oligomers and surfactants in Professor Manabu Seno's laboratory.

In total, about 15 laboratories at the University of Tokyo, each of which usually consists of one professor, one associate or assistant professor, and one or two instructors, are engaged or have some interest in research of synthesis, characterization and utilization of polymers.

Waseda University, located about 5 km west of the University of Tokyo, is one of the most distinguished and largest private universities in Japan and has several research groups working on polymer science. The laboratory of Professor Isao Shinohara has been developing methods for synthesizing graft and block copolymers that have microphase separated structures composed of hydrophobic and hydrophilic domains and that exhibit good properties for medical use. The group is also interested in the synthesis of polymers with high electric conductivity. Professor Eishun Tsuchida, has assembled a large and active research group which is involved with the synthesis of functional polymers, especially polymeric chelates, which has the potential as polymer catalysts and/or reversible carriers of molecular oxygen by complexing with metals.

Professor Akio Chiba and Associate Professor Koichi Ito have been working on the elucidation of polymer structures, mainly by x-ray crystallography and other spectroscopic methods.

Sophia University and Science University of Tokyo have campuses close to the center of Tokyo. The former is a few kilometers west of the Imperial Palace, while the latter is somewhere between Sophia University and University of Tokyo. At Sophia University, the laboratory of Professor Naoya Ogata, former vice-president of the university, and Associate Professor Kohei Sanui, is most important. It consists of a very large and important research group which is involved with studies of polycondensation and polyaddition reactions which led to the preparation of new polyamides, polyesters and other polymers which have unique functionalities and/or reactivities.

At the Science University of Tokyo, Professor Masatami Takeda has been interested in the synthesis of polyolefins with Ziegler-Natta catalysts as well as in the characterization of polymers by  $^{13}\text{C}$  NMR spectroscopy. Professor Tsuruta is now located at the Science University and Professor Junji Furukawa, Professor Emeritus of Kyoto University, has a laboratory at another campus of the Science University in Noda, a city on the outskirts of Tokyo near Chiba.

Midway between Sophia University and Waseda University, Tokyo Women's Medical College, is located. The Departments of Surgical Science and Medical Engineering are both headed by Professor Yasuhisa Sakurai formerly of the University of Tokyo. These groups have developed cooperative programs with laboratories in other universities; the departments have been contributing much to the progress of biomaterials chemistry. Medical technology of artificial organs developed by the medical group is matched with chemical methods for synthesizing polymers specially designed for the purpose and for studying interactions between living systems and polymers at the molecular level. The chemical methods were introduced by three staff members who came from the University of Tokyo and Waseda University. Associate Professor Toshihiro Akaike has recently moved to the Tokyo University of Agriculture and Technology.

Increasing interest in the study of biomedical materials is also demonstrated in the Institute of Medical and Dental Engineering, Tokyo Medical and Dental University. The Institute is about 1 km from the University of Tokyo and throughout its history, it has been creating new materials and apparatus especially designed for medical and dental use. Professor Eiichi Masuhara, Associate Professors Norio Nakabayashi and Hiroo Miyairi, Dr. Yoji Imai and senior members in the Institute have been concentrating on the utilization of synthetic polymers for these purposes.

In addition to the laboratories at the University of Tokyo, about ten more research groups in Central Tokyo are engaged in the development of new polymeric materials, methods and concepts of understanding synthetic and natural polymers.