November, 1992

Polymer Science in Finland

Otto Vogl, *University of Massachusetts - Amherst*
Johan J. Lindberg
Franciska Sundholm

Available at: https://works.bepress.com/otto_vogl/203/
Polymer Science in Finland

by J. Johan Lindberg (a), Franciska Sundholm (a) and Otto Vogl (b)

(a) Department of Polymer Chemistry, University of Helsinki, Mentininkatu 1A, SF-00170 Helsinki, Finland
(b) Polytechnic University, Six MetroTech Center, Brooklyn, NY 11201, U.S.A.

Finland is located in the northeastern part of Europe. It has a population of about 5 million people and has an area of about 350,000 square km (about 135,000 square miles). 20% of the area is water which consists of both lakes and rivers. Finland is bordered on the east by Russia, to the north by Norway and on the west by Sweden; Finland also borders on the Baltic Sea and the Gulf of Bothnia. Finland has 17 institutions of higher learning, the most important one being the University of Helsinki.

University of Helsinki

The University of Helsinki was founded in Turku (Abo) in 1640 as the Turku Academy. The Academy obtained a new building in 1817 but tragedy was to strike ten years later when a great fire raged in the city of Turku and the laboratories were destroyed. As a consequence, the University was transferred in 1827 from Turku, by proclamation of the Czar, to Helsinki, the then newly created capital of Finland. At that time Finland was an autonomous part of the Russian Empire.

The University of Helsinki now has 28,000 students, which represents 15% of the students of higher learning in Finland. The University has 445 associate and full professors and consists of 8 faculties and 20 independent institutes. The Department of Polymer Chemistry is part of the faculty of science, which is the University’s second largest faculty. This faculty consists of several departments, including the largest one of the university: the Department of Mathematics, Physics and Chemistry. A move is presently underway to build facilities for the Science Departments in the new Kumpula Campus. The Science Faculty has about 6200 students. Chemistry is taught in four departments; in addition there is an independent department of Radio Chemistry and the Department of Polymer Chemistry. The Department of Polymer Chemistry is involved in traditional work in wood and plastic chemistry and works in close cooperation with industry.

From 1640 on, there has been a chair for Natural Sciences at the Academy of Turku. In 1768, a chair was established dedicated entirely to chemistry, presently the chair of organic chemistry.

Originally, the chair in the Department of Chemistry consisted of only organic chemistry, physical chemistry and biochemistry and basic chemical education in Swedish, until chairs of radio chemistry and of wood and polymer chemistry were established in the 60’s and finally, the chair in analytical chemistry in 1973. The chair of polymer chemistry and the Department of Polymer Chemistry were established in 1961. The first head of the department was Professor J. Johan Lindberg, who was the head of the department for the next 20 years. In 1987, he was succeeded by Professor Franciska Sundholm.

The chemistry of polymeric materials, such as cellulose, lignin, phenolic resins, plastics and elastomers, has been studied in Finland for nearly a century. Today the consumption of polymeric materials, per capita, in Finland is the largest in the world. A few small academic institutes are educating polymer chemists. The Department of Polymer Chemistry at the University of Helsinki is the oldest and largest of these institutes, with a teaching staff of 2
Centers of Polymer Research

Opening of a New Year at the University of Helsinki

Prorektor and Otto Vogl

The Department of Polymer Chemistry: Lecture courses in fundamentals of polymer chemistry are given for second year students (about 100) every year. 15 to 20 students annually start their studies with Polymer Chemistry as the main subject in their third and fourth year. Lecture courses include polymer chemistry and physics, wood chemistry, theology and polymer technology. Laboratory courses are also included in the program. Specialized courses in textile and fiber chemistry, liquid crystalline polymers, conducting polymers, surface and colloid chemistry and the thermal degradation of polymers are given annually. In the past 20 years, about 300 students received Masters degrees in the department.

Analytical methods used in research include dynamic light scattering, differential scanning calorimetry, thermogravimetry, NMR and ESR spectroscopy, optical microscopy and thermostamography (pyrolysis gas chromatography). Recently the department has acquired a graphic work station.

The research activities of the department are closely related to the graduate education. The personnel include Professor Franciska Sundholm, Assistant Professor Heikki Tenhu, lecturers Jukka Marttunen, Matti Elomaa and Riitta Dammer; Professor Johan Lindberg is still active as a Professor Emeritus. In addition, the research staff includes Matti Lammi, Satu Niemi, Liisa Pirilä, Simo Salo, Kaari Saljama, Sirkka Maunu, Tisto Särme, Elina Vesterinen, Johanna Kinnunen, Tiina Tynnen, Jouko Harmaa, Robert Jansson, Heli Karhinen and Juha Solansari. The polymer chemistry program consists of compulsory as well as optional courses.

The research in the Department of Polymer Chemistry is related to the chemistry and physics of synthetic and natural polymers with specific research projects as follows: synthesis of new crosslinked polystyrenes; new styrene block copolymers; synthesis of functionalized, mesogenic derivatives of polystyrene; dynamics of polymer solutions; structure—property relationship in mesogenic polymers, especially the influence of the degree of polymerization and chain tacticity on mesomorphic properties; structure of hydrophilic polymer gels; pyrolytic degradation of synthetic and natural polymers; synthesis of modified alkyds; development of polyelectrolytes for use in polymer electrolyte fuel cells; interaction in polymer - polymer complexes and in tenside systems; polymer modeling for material properties.

Styrene copolymers are being investigated by Sundholm, Vaahbera and Tenhu. The elastic properties and the thermal stability of polystyrene are greatly enhanced by inserting siloxane blocks and/or crosslinks of various lengths in the polystyrene structure. Polystyrene also undergoes a multitude of reactions with low molecular weight compounds; with carefully chosen reagents it is possible to functionalize the polymer without interfering with the crosslinking. To the functionalized backbone various substituents are linked, the purpose of which is to modify properties, processibility and orientational behavior of the polymers.

Liquid crystalline polymers are being studied by Sundholm, Niemiela and Dammer. Mesogenic side chains are linked with flexible spacers to polystyrene, in order to determine the influence of the degree of substitution on polymer mesogenic properties. Numerous new polymers have been made.

Polymers for pharmaceutical purposes are being investigated by Marttunen. In a synthetic project, the preparation of redox polymers of the quinone type is being investigated. Autoxidation of antralin (1,8-bilhydroxy-n-anthraquinone) has been the most important compound for topical treatment of psoriasis. The action of psoriasis investigations is being carried out by Marttunen in collaboration with the Department of Dermatology both experimentally and theoretically.

The complex formation between polymers of different polarities and between polymers and ions or tensides are of potential interest for application in water and waste water purification and in the development of composite materials; this area is being investigated by Maunu, Kinnunen and Sundholm.

Following this work, the department has been connected to an inter-Nordic project investigating fuel cells (financed through the Nordic Council of Ministers); Maunu, Kinnunen and Sundholm are studying the conductivity of ion conducting materials to be used in
polyelectrolyte fuel cells. This work is done jointly with the
Laboratory for Physical and Electrochemistry at the Helsinki
University of Technology.

The synthesis of modified alkyls aims at products (paints) with
high solid content. The alkyls are modified by including mesogenic
aromatic ester groups in the polyester. The work is being done by
Jasinskas, Haavara and Sundholm.

Cellulose and wood are very important natural products and
products of importance in commerce in Finland. As a consequence,
cellulose and lignin are intensively investigated, particularly by
studying the dynamics of natural composites (wood and chitin) and
their components, which is done by Professor Lindberg. Lindberg
and Lauteri are investigating the drying of wood in cooperation
with the Danish Technical University and the Swedish Wood
Research Institute.

The effect of crosslinking on water-polymer interaction as well
as on polymer conformation and reactivity is studied spectro-
scopically for polymer solutions and hydrogels by Tenhu and
Turunen. Tenhu is a specialist in the use of spin labeling techniques
(ESR spectroscopy) and dynamic light scattering for the study of
polymer conformations. Recently rod-like polymers (poly-
Diacrylates) have been added to the list of polymers investigated.

Additional fundamental work is being carried out on the
pyrolysis and the burning of polymers (Elomaa). The pyrolytic
methods, for the identification and characterization of biomass and
their components, have been developed in cooperation with
scientists in Estonia (Estonian Academy of Sciences, Mihkel
Kaljurand) and Professor Charles C. Loehmuller, Duke University.
The application of thermochromatography and the correlation
chromatography through analysis of copolymers and blends is being
studied by Pilu and Elomaa.

Morphology, and especially the interaction between crystalline
and amorphous areas in linear and crosslinked polyethylene is being
studied by Sojamo, using solid state NMR spectroscopy, CP/MAS
and RSCP. From these measurements, the crystallinity, the lamellar
thickness and the role of branching and crosslinking can be deduced.

Helsinki University of Technology

Helsinki University — Main building in The Senate Square

The Helsinki University of Technology is one of the three
universities of technology in Finland. The other two are located in
Tampere and Lappeenranta. In addition there are faculties of
technology in two other universities: The University of Oulu and
the Abo Akademi in Turku. Helsinki University of Technology is
the oldest and the only one covering all branches of engineering and
architecture. More than 50% of all university students of technology
in Finland are studying at the Helsinki University of Technology.

In 1849 a Helsinki Technical School was founded “to offer
secondary school education to youngsters who wish to enter
industrial trades”. The school developed into a Polytechnic Institute
in 1879 and received university status in 1908. For a century the
university buildings were situated in central Helsinki until growth
made it necessary to build on new locations, Otaniemi, in the
township of Espoo, 10 km west of the city, became the site of the
new campus. In 1949 an Otaniemi master plan was developed,
which suited magnificently the milieu of Otaniemi. Building was
started in the ’50s; by 1972, all departments had moved into the
new premises. Now Helsinki University of Technology offers
higher education of technology and promotes research activities.
The University awards degrees in engineering and architecture.
The number of undergraduates is about 10,000; 1300 graduate students
are also studying at the Helsinki University of Technology.

The University has 6 faculties divided into a total of 17
departments. The Department of Chemistry, one of the largest of
the University, belongs to the Faculty of Material Science. The
Chemistry Department consists of seven laboratories: Biochemistry,
Microbiology, Biotechnology, Chemical Engineering, Inorganic
and Analytical Chemistry, Organic Chemistry, Physical Chemistry
and Electrochemistry, Industrial Chemistry and Polymer
The department of Forest Products Technology is also interdisciplinary nature and emphasizes process technology and other forest products which are polymers. The department of Chemistry is now headed by Professor Göran. Most of the work in Polymer Science is carried out in the laboratory of Industrial Chemistry and Polymer Technology. Some work is also going on in the Department of Physical Chemistry, in cooperation with Guilla Fabricius, Kjell Sandholm, and the study polymer modified electrodes, the kinetics and mass transfer of the electrodes covered by which may either an ion-exchanger or an electronically grafted material. The mass transport through a polymer with ion properties is being studied using mainly conductivity meters. Another part of this work concerns electrochemical and the properties of electronically conducting thiophenes. Research in the Department of Physical Chemistry related to Science includes electrochemistry related to membrane separations. It is concerned with the extraction from ligands, ion-exchange liquid membranes, liquid membranes, and liquid membranes, and the extraction of ligands, ion-exchange liquid membranes, liquid membranes, and ligands extraction. The technique of electrowinning involves the extraction of ligands and the extraction of ligands. Electrochemistry at the liquid interface sometimes involves polymer systems, with the extraction of ligands and the extraction of ligands. Electrochemistry at the liquid interface sometimes involves polymer systems, with the extraction of ligands.

The Laboratory of Industrial Chemistry and Polymer Technology is one of the seven laboratories of the Department of Chemistry. The full time faculty and staff of the laboratory numbers 11, including 8 with academic degrees. The laboratory teaching and research in the fields of organic and polymer chemistry, polymer technology, chemical engineering, and heterogen catalysis. Major new equipment available in continuous high pressure laboratory reactors for research liquid and gas chromatography, UV-IR spectrometers, polymerization reactors, injection molding equipment, tensile strength testing machines, viscometers and ion testing instruments for plastic materials. Other methods such as NMR, FTIR and mass spectrometers as well as analytical equipment are also available. Computing facilities are offered through the University computing center.

The Laboratory of Industrial Chemistry is led by Professor J.P. Berg, the research group for polymer technology by Dr. Jukka Seppälä. The research in polymer technology is basically reactive processing, general polymer research, conducted polymers. Blends of liquid crystalline polymers, lies on polymer blends. Specifically, the polymer research involves the utilization of various reactor types for polymerizations specific instruments for versatile copolymerizations in temperature ranges from -50°C to +90°C. The results of the research projects involves the Coordination Polymer Research Group which consists of the: a) studies of donors in propylene polymerization with highly active Ziegler-Natta catalysts involving the effects of various external silica donors and the catalyst behavior and the microstructure propylene; b) aim to correlate the structure of the catalysts and their relation to the polymerization effectiveness to better and the nature of the active catalyst centers; (c) polymerization by fractionation GPC and 13C NMR studies; d) theoretical applications to various technical problems by melt blending is
being studied using a twin-screw extruder. Blended samples are then injection molded. c) The rheology and morphology as well as the tensile and thermal properties of the blends are being investigated.

The following services are available in the Department of Polymer Technology: a) In processing: continuous polymerizations, injection molding, small scale extrusions, including film blowing, sheet forming, mixing in the melt, compression molding and milling. b) In characterization: the measurement of the molecular weight distribution, of the melt flow index, of the intrinsic viscosity, of the density, of the contact angle, of the infrared and ultraviolet spectrum. The following testing methods are available: stress-strain test, especially with high loads and at low and high temperatures; impact strength; temperature of deflection under load; Vicat softening temperature; hardness (Shore A and T, Brinnell) and water vapor transition.

**Tampere University Of Technology**

The Tampere University of Technology was founded in 1965. Polymer technology was taught from 1972 as part of the material science program and gradually separated to a special branch of technology. In 1973, an associate professor for non-metallic materials was appointed and in 1987 this position was elevated to a chair of polymer technology. The Institute for Plastics Technology was established in 1984. The aim of the institute is to provide basic and advanced information on polymers, plastics and composite materials which mechanical engineers require in industry. Students who specialize in plastics technology (Licentiate and Doctoral Candidates) also find subjects for their theses in the research program of the institute.

The research on plastics technology was initiated at Tampere University of Technology by Pertti Törmälä, who is also the first and present Professor of the chair. He is assisted in teaching and research by Associate Professor Antti Savolainen (chemistry and process technology) and Professor Arno Klemola (chemistry and process technology), several teaching and research assistants, one lecturer and some visiting docents. The teaching responsibilities include, in addition to the usual basic courses in polymer science and technology, advanced courses in polymer processing and plastic technology.

Among the research projects, the following ones should be mentioned: Material testing and structural studies on mineral wools, reinforced plastics and liquid crystal dynamics (Törmälä, Järvelä); Process technology concerning melt processes and extrusion coating (Savolainen, forming of filled composites and of metals and laminates (Esko Paikonen). The use of focused ultrasonic sound is also being studied by Savolainen. An especially intensive and internationally recognized research activity is carried out by Törmälä and his group on applied composite technology of medically used biodegradable polymer ligaments, on ceramic and micro-chirurgical biocomposites and on synthetic materials in orthopedics and traumatology.

**Abo Academy**

Abo Academy (founded in 1640 in Turku) is a university providing special education for the Swedish-speaking minority in Finland (6% of the population). Abo Academy has six faculties, two of which are teaching chemistry: the Faculty of Science and the Faculty of Chemical Engineering. A chair of technical polymer chemistry was founded within the Faculty of Science in 1975. At present, the chair is being held by Professor Bengt Stenhund. As Stenhund is serving his second period as the Rector of the University, Jan Näsmi is acting professor. Näsmi is assisted in teaching and research by two Assistant Professors, Jan-Eric Stenhund and Carl-E Wilen and by several visiting docents and by teaching and research assistants. In addition to basic courses in polymer science and technology, advanced courses in adhesion and adhesive technology, polymer materials, polymer composites, synthesis strategy plans and reviews on current polymer research are given. Annually, about 15 students carry out their diploma work in the field of polymer technology.

**Lappeenranta University**

At the Lappeenranta University of Technology (founded 1979) basic polymer technology is being taught. For some years under the direction of Professor Matti Lindström, a research group has been working on problems concerning physical properties and stability behavior of polymer membranes for ultrafiltration used in the pulp industry.

The research activities reflect the national and international growth of the polymer field: studies of polymer composites and their morphological and interfacial properties to control mechanical electrical, thermal and chemical properties. Investigations are under way to improve material for dental surgery. New functio polypropylene by Ziegler–Natta catalysis, modification of polymers and adhesion to perform electron beam processing of polymers and master barrier and diffusion properties of polymers are also being investigated.

In addition to the above research activities, several research groups, mainly at the Department of Mechanics of Helsinki University of Technology, the Tampere University, the Lappeenranta University of Technology, the University of Oulu and the State Research Center at Otsaniemi are involved in fundamental and applied research on plastic composites.

In conclusion, teaching and research in polymer science and technology in Finland is not only performed to fulfill industrial demands at home, but also to compete on an international level. Academic work and contacts with foreign laboratories in the polymer field is sponsored by state organizations, the Finnish Academy Science of the TEKES and NESTE foundations, and by some small private foundations. The international contacts of Finnish scholars the polymer and plastics fields are therefore quite frequent. At present the brain drain of polymer chemists and engineers from Finland which was at one time a problem, is now not very noticeable. Significant economic recession and further intense international contacts through the EEC will certainly influence these problems the coming years.