1992

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Johan J. Lindberg, Franciska Sundholm and Otto Vogl, Polymer Science in Finland, Polymer News, 17(9), 289-293 (1992)**32. Johan J. Lindberg, Franciska Sundholm and Otto Vogl, *Polymer Science in Finland,* Polymer News, 17(9), 289-293 (1992)**

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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 170,000 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 chairs 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 1967. 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 Franscika 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

Polymer News, 1992, Vol. 17, pp. 289–293
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Opening of a New Year at the University of Helsinki

professors, 3 lecturers and 8 docents; it has 25 graduate students. The department now consists of offices, laboratories and a library in the Borgstroen Bacco Mill building at Meritullinkatu 1A.

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, rheology 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 thermochromatography (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 Martinmaa, Matti Elomaa and Ritva Dammert; Professor Johan Lindberg is still active as a Professor Emeritus. In addition, the research staff includes Matti Laanterä, Satu Niemelä, Liisa Plit, Simo Salo, Kaari Soljamo, Sirkka Maunu, Timo Särme, Elina Vesterinen, Johanna Kinnunen, Taina Turunen, Jouni Hamara, Robert Jansson, Heli Karhinen and Juha Solasaari. 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, Vaahtera and Tenhu. The elastic properties and the thermal stability

Prorector and Otto Vogl

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, Niemelä and Dammert. 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 Martinmaa. In a synthetic project, the preparation of redox polymers of the quinone type is being investigated. Autoxidation of antralin (1,8-bihydroxy-n-anthrone) has been the most important compound for topical treatment of psoriasis. The action of psoriasis investigations is being carried out by Martinmaa 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 Mainu, 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

Department of Polymer Chemistry, University of Helsinki

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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 alkyds aims at products (paints) with high solid content. The alkyds are modified by including mesogenic aromatic ester groups in the polyester. The work is being done by Jansson, Hamara 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 Laaterä 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 spectroscopically for polymer solutions and hydrogels by Tenhu and Turunen. Tenhu is a specialist in the use of spin labelling techniques (ESR spectroscopy) and dynamic light scattering for the study of polymer conformations. Recently rod-like polymers (polyisocyanates) 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. Lochmüller, Duke University. The application of thermochromatography and the correlation chromatography through analysis of coploymers and blends is being studied by Plit and Elomaa.

Morphology, and especially the interaction between crystalline and amorphous areas in linear and crosslinked polyethylene is being studied by Soljamo, using solid state NMR spectroscopy, CP/MAS and IRCP. 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 Helsinki University of Technology Main Building in Otaniemi, Espoo.

y. The department of Forest Products Technology is also lisciplinary nature and emphasizes process technology wood and other forest products which are polymers.

partment of Chemistry is now headed by Professor Gören . Most of the work in Polymer Science is carried out in the of Industrial Chemistry and Polymer Technology. some work is also going on in the Department of Physical . Gören Sundholm, in cooperation with Gunilla Fabricius Kyösti Kontturi, is studying polymer modified electrodes, the kinetics and mass transfer of the electrodes covered by which may either an ion-exchanger or an electronically g material. The mass transport through a polymer with ion- properties is being studied using mainly conductivity ients. Another part of this work concerns electrochemical and the properties of electronically conducting thiophenes. search in the Department of Physical Chemistry related to Science includes electrochemistry related to membrane . It is concerned with the extraction of lignosulfonates pported liquid membranes. Lignosulfonates can be from an acidic aqueous into an organic phase using long phatic amines. Therapeutic systems of transthermal drug systems are also being investigated. Electrochemistry at d liquid interface sometimes involves polymer systems, ; electro-assisted membrane separations of proteins and the ransfer across bilayer lipid membranes.

Laboratory of Industrial Chemistry and Polymer gy is one of the seven laboratories of the Department of l Engineering. The full time faculty and staff of the y numbers 11, including 8 with academic degrees. The olves teaching and research in the fields of organic and chemical technology, polymer technology, chemical engineering and heterogenous catalysis. Major new equip- available in continuous high pressure laboratory reactors for research liquid and gas chromatography, UV-, IR neters, polymerization reactors, injection molding equip- truders, tensile strength testing machines, viscometers and ther testing instruments for plastic materials. Other nts, such as NMR-, FTIR and mass spectrometers as well ial, analytical equipments are also available. Computing are offered through the University computing center.

Laboratory of Industrial Chemistry is led by Professor J.P. erg, the research group for polymer technology by r Jukka Seppälä. The research in polymer technology basically reactive processing, general polymer research, conducted polymers, blends of liquid crystalline polymers, lies on polymer blends. Specifically, the polymer research the utilization of various reactor types for polymerizations pecific instruments for versatile copolymerizations in ture ranges from -50°C to +90°C.

of the research projects involves the *Coordination Poly- ion Research Group* which consists of the: a) studies of donors in propylene polymerization with highly active -Natta catalysts involving the effects of various external silane donors and the catalyst behavior and the micro structure propylene; b) aim to correlate the structure of the external nd its relation to the polymerization effectiveness to better and the nature of the active catalyst centers; (c) polymer erization by fractionation GPC and 13C NMR studies; d) the preparation and the study of EP rubbers: copolymerization of ethylene and propylene using a high yield Ziegler-Natta catalyst; effects of various catalysts and different polymerization conditions on the composition and on the microstructure of EP rubber; rubbers are characterized mainly by FTIR and 13C NMR methods; (e) preparation, characterization of hetero-phase propylene-ethylene copolymers; hetero-phase propylene-ethylene copolymers (block polypropylene) are prepared using a high yield Ziegler-Natta catalyst; effects of the catalyst aging and the monomer feed composition on polymer structure and catalyst activity is being studied; polymers are characterized by 13C NMR, FTIR, GPC, SEM and by fractionation; a special fractionation equipment is under development; f) copolymerization of propylene with new exotic monomers; a large literature study of the co- and terpolymerization of propylene with various other monomers is now underway.

Fabrication of adhesives using *reactive processing* methods is being studied; processing methods to graft oligomers with functional groups onto polyethylene in an extruder; first attempts are being made to study radical mechanisms and kinetics of oligomerization of suitable monomers. The target of the studies on *graft polymerization of vinyl monomers on ethylene* polymers to obtain information on reaction kinetics between specific unsaturated acids or silanes and ethylene polymers: a.) Grafting reactions sometimes proceed by free radical mechanism and involve chain transfer reactions; i) initiators that abstract hydrogen efficiently are used as a source of primary radicals; ii) experiments are carried out in a single screw extruder. b.) A theoretical kinetic model was developed to simulate the reactions in extruders; i) relevant kinetic data have been collected from the literature; ii) model predictions are compared with available experimental data from plant scale equipment; iii) a model was used to study the effect of temperature, screw speed and feed concentrations on the extent of grafting. c.) Detailed experimental studies have also been made to verify the validity of these models.

The interest in *ion conducting polymers* (Lauri Kuutti, Jukka Sepaelae) is to find out the influence of the polymer structure on the mechanism of ion conduction in polymers-salt complexes by using molecular modeling. a.) Molecular mechanics calculation and computer graphics have been utilized in order to model interactions between a number of helix-structured polyethers and lithium ions: i) structures of the helix and double helix polyethers were optimized by minimizing the intra- and intermolecular energies; ii) energies of interaction between the ions and the optimized polyethers were compared with experimental conductivity measurements; iii) polyethers such as poly(ethylene oxide), poly(propylene oxide), poly(butylene oxide) and poly(styrene oxide) were studied. b.) A model has been constructed in which the deforming influence of the ion on the helix structure of the polyethers have been taken into consideration. c.) Molecular models are being used in this study of the electric conduction properties of polyether-salt systems. d.) Blends of liquid crystalline polymers with thermal plastics (Markku Heino, Camilla Kapanen and Jukka R. Seppaelae) are being investigated.

Blends of *thermotropic liquid crystalline polymers* with some thermal plastics are also being studied. a.) Thermotropic liquid crystalline polymers form liquid crystals in the molten state. (usually they are copolyesters consisting of p-hydroxybenzoic acid moieties, they have low melt viscosity, excellent mechanical and thermal properties and chemical resistance.) b.) The possibility of the transfer of these properties to various thermal plastics 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 tests, 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, Brinell) 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 Aarno 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 (Sorvolainen, forming of filled composites and of metals and laminates (Esko Pääkönen). The use of focused ultra sound is also being studied by Sorvolainen. 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 orthopedy 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 Stenlund. As Stenlund is serving his second period as the Rector of the University,

Abo Akademi, Main Building

Jan Näsman is acting professor. Näsman is assisted in teaching a research by two Assistant Professors, Jan-Erik Stenholm and Carl-E Wilen and by several visiting docents and by teaching and resea assistants. In addition to basic courses in polymer science a technology, advanced courses in adhesion and adhesive technolo polymer materials, polymer composites, synthesis strategy plann and reviews on current polymer research are given. Annually, abou students carry out their diploma work in the field of polyr technology.

Lappeenranta University

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

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

In addition to the above research activities, several otl research groups, mainly at the Department of Mechanics of t Helsinki University of Technology, the Tampere University, t Lappeenranta University of Technology, the University of Oulo a the State Research Center at Otaniemi are involved in fundamen and applied research on plastic composites.

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