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Royal Institute of Technology: Department of Polymer Technology

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Royal Institute of Technology: Department of Polymer Technology

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The Department of Polymer Technology of the Royal Institute of Technology in Stockholm has, over the last decade, become a major institution of teaching and research in polymer science. The department has briefly been described in one of the earlier articles in *Polymer News* entitled "Polymer Science in Sweden."

The Department of Polymer Technology in Stockholm is now 30 years old. It is the oldest and largest department of its kind in Scandinavia. The research program has a long history, starting in the early 1960s. Polymer research at the department focuses on chemistry, physics and mechanical properties of different kinds of polymers (e.g. biopolymers, thermoplastics, thermosets, elastomers and composites). The Department of Polymer Technology has research and teaching activities covering most fields of polymer technology. In addition, coating technology and processing of polymers and composites are also important areas of research.

The research programs consist of the following areas:

Synthesis and Characterization of New Polymers
Modification of Polymers
Degradation Studies of Stable and Degradable Polymers
Environmental Impact on Degradable Polymers
Mechanical Properties of Polymers
Non-linear Viscosity of Oriented Polymers
Chemistry of Thin Films
Process—Structure—Property Relations of Polymers
Physics of Oriented Polymer Melts

The research programs are supported by the Swedish Research Council, by industries (primarily Swedish industries) and by private foundations. The Department of Polymer Technology has extensive international contacts and active international cooperation in research and teaching.

The Department is very well equipped with numerous instruments for IR, UV and thermal mechanical spectroscopy, thermogravimetry, electron microscopy and polymer processing. It also has excellent equipment for chromatographic analyses; the Department has facilities for the determination of molecular weight (absolute as well as relative). Additional capabilities exist to determine the purity of polymers, the contents of additives, type of volatile and nonvolatile low molecular weight compounds in synthetic and natural polymers. Equipment in polymer spectroscopy includes FTIR, FT-Raman, UV-VIS spectrometry and luminescene spectrometry. For thermal analysis, the Department has three different scanning calorimeters, and, for thermal-optical analysis and optical microscopy, it has polarized light interference contrast, phase contrast conoscopy using Bertrand lenses and various tilt compensators. The studies of crystallization kinetics as well as the characterization of liquid crystalline polymers are being done by thermo-optical analysis.

Equipment is available for "in-situ" polymerization of mesomorphic monomers. The mechanical instrumentations include equipment for mechanical characterization of thermoplastic, thermosets and rubbers. For the static measurements a stress-strain tester is available; creep equipment and stress relaxometers for measurements between 50°C and 200°C as well as for dynamic mechanical measurements are available. The Department has equipment for polymer processing (injection molding machines, extruders, calanders, presses, etc.), which are mainly used for basic education and sample preparation. The Department also has special equipment for studies of the mechanical, physical and solidification behavior of oriented polymer melts. For the analysis of the flow behavior of polymer melts and process modeling, the equipment of the department has access to several advanced computer programs.

The Department of Polymer Technology has teaching programs on both the undergraduate and graduate level. It has a department staff of four professors, three associate professors and one assistant professor. It has presently 30 graduate students and 7 temporary employees. Around 20 part-time graduate students are working on their theses in various Scandinavian countries. The department is assisted by 8 persons of technical and administrative staff; since 1971, 40 Ph.D. degrees have been awarded. A major change occurred about 5 years ago when the new department building became available; the department, which for almost 25 years had consisted of one professorship held by Professor Bengt Rånby, was

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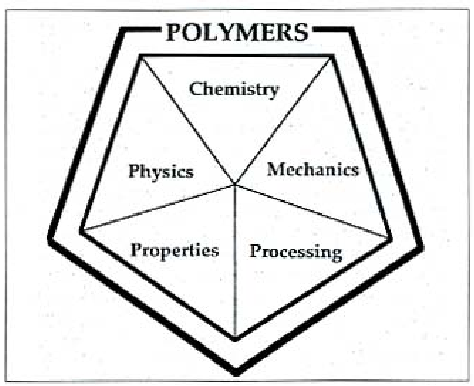
Royal Institute of Technology Main Building

The Department of Polymer Technology, Royal Institute of Technology

enlarged to four professorships, two actual university professors and two additional professors supported by industry.

The following courses are given in the undergraduate program. General courses in polymer materials: "Chemistry of Polymers," "Physics of Polymers," "Polymer Technology," "Biopolymers," "Work Science in Polymer Industry," "Surface Coatings Chemistry," "Mechanical Properties and Testing of Polymers," and "Polymer Engineering Materials" and "Processing of Polymers."

Graduate courses consist of "Introduction to Polymer Chemistry," "Polymer Chemistry," "Polymer Physics," and "Polymer Mechanics." In addition courses on "Polymer Synthesis," "Specialty Polymers," "Biopolymers," "Polymer Research and Development," "Current Polymer Problems," "New Polymers with Extreme Properties," "Polymer Spectroscopy," "Optical Microscopy and Optical Properties," "Thermal Analyses of Polymers," "Industrial Adhesion Problems," "Melt Rheology and Process Modeling," "Rubber Science Technology" and "Physics of Crytalline Polymers."



Department of Polymer Technology

Research in the Department of Polymer Technology consists of research in chemistry, physics, mechanics, properties and processing of polymers; it has 7 active research groups.

Ann-Christine Albertsson, Professor of Polymer Technology, has been the head of the department since 1986. Her research interests include the biodegradation of synthetic polymers, environmental degradation of polymers, functional polymers, macromolecules as drugs, polymer release agents for biologically active compounds, polymerizable ultraviolet absorbers, oligomeric and macromolecular stabilizers, synthesis and degradation of block and random polyesters and polymeric anhydrides, ketenes as polymer intermediates, advanced systems for polymers, life cycle design for polymer materials and waste problems. In her current research, the design of polymeric materials for long life time, the stability of polymer properties and controlled degradation of polymers is being investigated.

The characterization and degradation studies of stable and degradable polymers and the identification of their degradation products as well as waste problems involving polymeric materials are being pursued. Ring opening polymerization of cyclic esters and carbonate homopolymers and copolymers are being investigated. Synthesis, characterization and testing of new synthetic polymers are being pursued. The objective is to combine mechanical strength and elasticity with controlled degradability by hydrolysis. Work is being done with polymers having ester and anhydride groups in the polymer main chain. Of particular interest is the synthesis, characterization and degradation of aliphatic polyesters and polyanhydrides. Special methods have been developed to study the products of polymer degradation and to detect them where volatile organic acid and alcohols are evolved in order to understand the different degradation mechanisms.

An HPLC system was also developed to detect polyamines in degraded casein. This understanding is important to explain the cause of bad odor in some buildings and to identify the cause as coming from floor covering materials.

Anders Hult, Professor of Coating Technology, has research interests in the chemistry of thin polymer films, surface modifi-

Anders Hult

cation of polymers, coating chemistry, synthesis and characterization of liquid crystalline polymers.

Curing kinetics in extremely fast curing reaction will affect the formation of internal stresses in the film and influences the physical properties of polymers .

Surface modifications of polymers are being studied in two directions: a) Photoinitiated interfacial polymerization, b) With surface active macromonomers. The interest is in the preparation of polymers where the surfaces contain photostabilizers. It was shown that the surfaces maintain the activities of the attached molecule. Surface active macromonomers have been utilized to modify polymer surfaces both by simple blending technique or by polymerizable Langmuir-Blodgett films.

Liquid crystalline polymers have also been synthesized mainly from liquid crystalline aromatic polyethers (main chain vinyl ethers), and styryl ethers (side chain). Work on resin chemistry is carried out in three areas: allyl ether modified resins, resins for cationic curing and liquid crystalline resins.

Jan-Fredrik Jansson, Professor of Polymer Materials, is interested in relaxation phenomena, non-linear viscoelasticity, deformation and fracture processes in polyethylene, the influence of processing conditions on the properties of polymer materials, the fracture in fiber composites, mechanical long term properties of rubber materials and the medical and dental application of polymer materials. The following programs are now being actively pursued: solidification kinetics of amorphous polymers/enthalpy relaxation, pressure-temperature-shear rate-time behaviour of oriented polymer melts, shear induced crystallization, nonlinear viscoelasticity of

Jan-Fredrik Jansson

oriented polymers at biaxial stresses, computer simulation of polymer melt flow, silicate polymers and the prediction of non-isotropic properties of polymer products.

Methods have been developed for the study of orientation and coiling kinetics in polymer melts. Measurements of warpage in polymer products using holography determination of the thermal expansion coefficient at very low temperatures and the orientation of polymers using holography were made. The fracture sequences in roving based composites have been defined and have been related to the viscoelastic properties of the matrix.

The intrastrand condition including staring magnification, the interphase and interphase interactions, the influence of the thermal prehistory and annealing on the sub-Tg endotherm of polystyrene has been determined.

Jan-Anders E. Månson, Professor of Polymer and Composites Processing, has research interests in process-structure property relationships of high performance polymers and polymer based composites with emphasis on internal stress generation and polymer selfdiffusion.

Jan-Anders E. Månson

Extensive research has been carried out on sources and driving forces for internal stress degeneration with emphasis on the interaction between processing conditions, solidification kinetics and the intrinsic properties of the constituents. This work has led to a modeling stage for internal stress to be used for both neat polymers and composite materials, processes under isothermal/non-isothermal conditions. The influences of non-isothermal and non-balanced solidification conditions on the laminate quality, addition morphology and mechanical properties are also being studied. Rheological studies of high temperature resins are being performed for the simulation and modeling of conditions present during the consolidation of thermal plastic composites. Investigations are also being carried out for injection molding of high temperature materials as well as for processing advanced fiber systems which utilize high production rate techniques.

Bengt Rånby, Professor Emeritus of Polymer Technology, was the head of the Department from 1961 to 1986. His research involved the study of morphology, structure and reaction of native cellulose, the modifications of cellulose, starch and other polysaccharides by graft copolymerization. It also included the investigation of the free radical reactions in polymerization and degradation as studied by ESR spectroscopy. Photodegradation, photooxidation and photostabilization of polymers were also

Bengt Rånby

investigated, particularly as the stability of the polymers is effected by the reaction of polymers with ozone, singlet oxygen and atomic oxygen. UV curing of surface coatings, photoinitiated crosslinking and surface modification of polyolefins and other synthetic polymers have also been investigated as were the electrical properties and electrical fields induced phenomena in polymers as insulating materials.

The present research interest is in photoinitiated crosslinking of polyethylene with UV light, the modification of polymer surfaces by photoinitiated graft copolymerization. Surface modification of cellulose fibers by chemically initiated grafting is also being investigated as are the chemical changes in polymers used as electrical insulation which is studied by electro-luminescence.

The problem of the microfibrillar morphology of native cellulose was resolved. It was also discovered that the native cellulose crystal structure I, is a thermal dynamically unstable phase, whereas mercerized cellulose II, is a stable phase. It was also found that the crystalline phase of isotactic poly(4-methyl-1-pentene) has a lower density than the amorphous phase. Photodegradation mechanisms of polyolefins, polydienes and polyesters have also been clarified and new redox initiators in aqueous solutions for graft copolymerizations on 2 polysaccharides have been found. The reaction mechanisms of free radical initiated propagation of copolymerizations using ESR spectroscopy was applied to flow systems. UV photocrosslinking, photoinitiated crosslinking of polyethylene and of diene copolymers and of unsaturated polymers were carried

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out using UV radiation. A continuous new method for the surface modification of polymer fibers and films using photoinitiated grafting with UV light was invented.

Ulf W. Gedde, Associate Professor of Polymer Technology, is interested in polymer physics of crystalline and liquid crystalline polymers with emphasis on molecular structure, solidification morphology and electrical properties of polymers and crystalline polymer composites. Of particular interest in crystalline polymers is the study of binary blends of linear and branched polyethylene including their crystallization kinetics, morphology, mechanical and electrical properties. Shear induced crystallization of polymers is also being studied. The work on liquid crystalline polymers follows three lines: processing—morphology—properties of main chain polyesters, phase transitions in main chain polyethers, side chain polymers, and the synthesis of ordering in functional liquid crystal polymers. The work on polymer electrical properties is concentrated on three different topics.

Ulf W. Gedde

The effects of morphology in crystalline polymers on the resistance towards partial discharges, the effect of crystal structure on glassy amorphous polymers (copolymers based on styrene and substituted styrene monomers and polyarylether-ketones) on the resistance towards partial discharge. The effect of the chain structure on the crosslinking kinetics of polyethylene and on their electrical stability is being investigated.

Sigbritt Karlsson, Assistant Professor of Polymer Technology, is interested in biopolymers and biomaterials and the degradation of them in abiotic and biotic environments. The development of