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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 Viscoelasticity 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 luminescence 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 and conoscopic 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 thermal-optical analysis.

Equipment is available for "in-situ" polymerization of monomeric monomers. The mechanical instrumentation includes equipment for mechanical characterization of thermoplastic thermostets 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, calenders, presses, etc.), which is 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 30 part-time graduate students are working on their theses in various Scandinavian countries. The department is assisted by 8 person years 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 Ranby, was

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Centres of Polymer Research

Royal Institute of Technology Main Building

The Department of Polymer Technology, Royal Institute of Technology

Rubber Science Technology" and "Physics of Crystalline Polymers." 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, polyurethane ultraviolet absorbers, oligomeric and macromolecular stabilizers, synthesis and degradation of block and random copolymers and polymeric anhydrides, ketones 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 term 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 acids and alcohols are evolved in order to understand the different degradation mechanisms.

An HPLC system was also developed to detect polyamines in degraded cases. 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 Huls, Professor of Coating Technology, has research interests in the chemistry of thin polymer films, surface modifi-
Curing kinetics in extremely fast curing reaction will affect the formation of internal stresses in the film and influences the physical properties of polymer.

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 chains). Work on resin chemistry is carried out in three areas: allyl ether modified resins, resins for automotive 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 polymers, 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/crystallization, relaxation, pressure-temperature-time rate-change behavior of oriented polymer melts, shear-induced crystallization, non-linear viscoelasticity of oriented polymers at biaxial stress, computer simulation of polymer melt flow, solid-state polymers and the prediction of non-isotropic properties of polymer products.

Methods have been developed for the study of orientation and cooling 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 razing based composites have been defined and have been related to the viscoelastic properties of the matrix.

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

Jan-Anders E. Måsson, 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 self-stabilization.

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 condition. This work has led to a modeling stage for internal stress to be used for both neat polymers and composite materials, processes under isothermal and non-isothermal conditions. The influence 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 therms systems which utilize high production rate techniques.

Bengt Ránby, 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 photo-stabilization of polymers were also
investigated, particularly as the stability of the polymers is affected
by the reaction of polymers with ozone, singlet oxygen and atomic
oxygen. UV curing of surface coatings, photoinitiated crosslinking
and surface modification of polyurethanes 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
microcrystalline 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-pyrrolidones have been found. The
reaction mechanisms of free radical initiated propagation of copoly-
merizations using ESR spectroscopy was applied to flow systems.
UV photocrosslinking, photoinitiated crosslinking of polyethylene
and of diene copolymers and of unsaturated polymers were carried
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
copolymers, phase transitions in main chain polymers, side chain
polymers, and the synthesis of ordering in functional liquid crystal
polymers. The work on polymer electrical properties is concen-
trated on three different topics.

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 polysiloxane—ketone) 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.

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