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Polymer Science in Czechoslovakia II Universities in The Czech Socialist Republic

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Czechoslovakia, a country of about 15 million inhabitants located in Central Europe, consists of two federal states: the Czech and Slovak Socialist Republics. The Czech Socialist Republic has two provinces: Bohemia and Moravia. Polymer science has a long tradition in Czechoslovakia, particularly in the Czech Socialist Republic; the first rubber-processing factory originated as early as 1887 in Bohemia, where most of the chemical industry of the former Austro-Hungarian Empire was concentrated. Additional rubber-processing factories, the production of phenol-formaldehyde, casein-formaldehyde resins, a rather extensive shoe-making industry, and the production of paints developed in Bohemia and Moravia, thus forming an important polymer-related branch of the Czechoslovakian industry before World War II. The importance of the polymer-producing and processing industry increased in the post-war period along with the world-wide development of polymer chemistry and technology. This development caused a substantial increase of the activities in research and education in polymer chemistry, polymer processing, and polymer technology in the 1940s and 1950s. Polymer science has now established a firm position at universities and research institutes of the

Czechoslovak Socialist Republic.

This article describes the activities in polymer science at universities of the Czech Socialist Republic. The activities in Slovak universities and research institutes, the Polymer Institute of the Slovak Academy of Sciences in Bratislava and the Institute of Macromolecular Chemistry of the Czechoslovak Academy of Sciences in Prague have already been reviewed in three previous articles published in *Polymer News* in 1984 and 1986.

Additional basic polymer research is also carried out in research institutes in Czechoslovakia, in the Czech Socialist Republic, whose primary objectives is applied polymer research; scientific activities in polymer science in these institutions will be covered in a separate article.

PRAGUE INSTITUTE OF CHEMICAL TECHNOLOGY

Department of Polymers
Faculty of Chemical Technology

University education in macromolecular chemistry and polymer science started in Prague, the capital of Czechoslovakia, in the late 1940s. In 1949, the Department of Plastics

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Prague Institute of Chemical Technology

was founded at the Prague Institute of Chemical Technology under the leadership of Professor Otto Wichterle. Here the first generations of Czech polymer scientists were educated. In 1953, the Laboratory of Rubber and Plastics Processing was founded under the direction of Professor Ivan Franta. In 1960, these two departments were reorganized to form the Department of Macromolecular Chemistry, headed by Professor Jaroslav Káral, and the Department of Rubber and Plastics Technology, headed by Professor Ivan Franta. In 1971, these departments were unified to form the Department of Polymers, headed by Professor Jaroslav Káral until 1975, and subsequently by Professor Jaroslav Králíček. Since its creation, more than 1,000 M.S. and about 100 Ph.D. students in polymer science and technology have graduated from the Prague Institute of Chemical Technology.

The scientific work of the Department of Polymers is focused on fundamental research in two major areas: (a) Macromolecular chemistry: formation and transformation of macromolecular compounds and systems, and (b) Structure/property relationship of polymeric materials, especially the optimization of their properties.

Two research groups are active in macromolecular chemistry. One group is working under the leadership of Professor Jaroslav Králíček. It consists of Dr. Jaroslava Dvořáková-Kondelíková, Dr. Jan Roda, Dr. Irena Prokopová, and Dr. Antonín Moucha; the group is engaged in the synthesis and the study of the properties of lactam-based polyamides. The initiation of the anionic polymerization of lactams has been studied and numerous new initiating systems have been designed. Initiators based on aluminum complexes have been used for the continuous polymerization of ϵ -caprolactam and for the preparation of massive blocks of polyamides.

The mechanism of anionic polymerization of various substituted lactams and bislactams is also being studied. This type of research in lactam polymerization also involves copolymerizations of ϵ -caprolactams and 2-pyrrolidone with higher cyclic lactams using a number of different initiating systems which function by different polymerization mechanisms. A new HPLC method has been designed for determining cyclic oligomers and co-oligomers of lactams. The effect of monomer purity and other impurities on the lactam polymerization and the resulting properties of the polyamides is being investigated.

Associate Professor Budimír Veruovič with Professor Jaroslav Králíček in cooperation with Professor Vladimír

Kubánek (the Director of the Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Prague) are studying synthesis and properties of polymeric sorbents and their application in sorption processes and in immobilization of enzymes and cells.

Work of the second group is coordinated by Associate Professor Bohumil Bednář; it is focused on synthesis, characterization, and application of polymers with reactive groups. Special attention is paid to their application in electronics.

The solution properties of block copolymers are being studied by Associate Professor Bohumil Bednář with his group employing light scattering techniques, membrane osmometry, and gel permeation chromatography with an on-line low angle laser light scattering detector. Fluorescence measurements are being carried out to elucidate a micellization equilibrium of block copolymers in selective solvents.

Associate Professor Bohumil Bednář with Dr. Jaromír Zachoval, and Dr. Vladimír Maroušek are interested in radiation chemistry of reactive polymers with special emphasis on their use in electronic applications as photoresists, electron beam resists, and X-ray resists. The synthesis of polyimides and similar high-temperature resistant polymers for their application in other uses of microelectronic applications are also being studied.

Dr. Vladimír Maroušek has been interested in synthesis, characterization, and application of telechelic polybutadienes and polymeric sorbents based on 2,3-epithiopropyl methacrylate copolymers.



Old Prague

Three different groups in the same Institute deal with problems related to polymer processing and structure-property relationships.

Associate Professor Vratislav Ducháček with Dr. Bohumil Meissner, Dr. Jan Šimek, Dr. Antonín Kuta and their co-workers are studying the formation, properties, and stability of crosslinked and modified polymeric systems, especially those based on selected elastomers and on poly(vinyl chloride). Studies of kinetics and mechanism of sulfur and thiram vulcanization of elastomers, radiation crosslinking and modification of selected polymers such as polyolefins, poly(vinyl chloride), and fluorinated polymers, modification of poly(vinyl chloride) by crosslinking, particulate filler



Old City Hall, Prague

reinforcement, and blending with other polymers, crosslinking and reinforcement of polybutadiene-based liquid rubbers are also being carried out. The investigation of the stability of elastomeric systems in relation to their service-life also belongs to the area of interest of this research group.

Dr. Zdeněk Vymazal, Dr. Zdena Vymazalová, and Dr. Čeněk Jirkal under the present leadership of Associate Professor Vratislav Ducháček deal with the study of the thermal and photostability of poly(vinyl chloride), one of the most important polymers produced in Czechoslovakia. They are investigating the mechanisms of PVC stabilization with various metal-containing organic and complex compounds. The complicated scheme of reactions involved in the stabilization of poly(vinyl chloride) is also being studied with respect to synergistic or antagonistic effects caused by combinations of stabilizers or their reaction products. Attention is also paid to the optimization of stabilizing systems by computation. Stabilizers for products used in medical and other special applications are also being investigated.

Under the leadership of Associate Professor Miroslav Schätz, the group of Associated Professor Petr Vondráček, Dr. Marta Heidingsfeldová, Dr. Petr Hron, Dr. Miroslav Ašman, and their coworkers is concerned with the study and use of silicone rubbers. One area of research of this group is the investigation of new ways of producing new types of siloxane polymers and their modification by hydrosilylation crosslinking. The theoretical basis of silicone rubber compounding is also being studied with special emphasis on the mechanism of silica-silicone rubber interaction and the possi-

bilities of controlling and optimizing these interactions. The kinetics and mechanism of the formation of polysiloxane networks by hydrosilylation, electron beam irradiation or condensation vulcanization are also being investigated. High-temperature-durability of silicone rubbers is also an area of interest. The work of this group is also involved with the optimization of the properties and the processing procedures for silicone rubbers for highly demanding applications, such as in medicine and in electronics.

Crosslinking of polyolefins and poly(vinyl chloride) by organofunctional silanes is also being studied. In close cooperation with the Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Prague, the mechanical, surface and transport properties of the hydrophilized, silicone rubber, filled with a hydrogel polymeric filler are being investigated.

The Joint Laboratory of Material Research of Polymers of the Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, and the Faculty of Chemical Technology at the Prague Institute of Chemical Technology, was established in 1985. The research group of the Department of Polymers headed by Associate Professor Petr Vondráček is involved in the investigation of material properties of the crosslinked polymeric systems, while the other group of the Institute of Macromolecular Chemistry, headed by Dr. Josef Kovář, is studying rheological properties of polymer blends and other thermoplastic materials.

CHARLES UNIVERSITY, PRAGUE

Department of Physical Chemistry
Faculty of Sciences

Polymer research at the Charles University was started in the Faculty of Sciences of the Charles University by Associate Professor Ivo Kössler in the early 1960s. Between 1969 and 1972, the Department of Macromolecular Chemistry was established. Since 1972, polymer research and education has been part of the activities of the Department of Physical Chemistry, headed by Professor Jiří Dvořák. Up to the pres-



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ent, about 70 M.S. and 15 Ph.D. students have graduated in polymer chemistry from the Faculty of Science of the Charles University.

At the present time, the group of macromolecular chemistry is directed by Assistant Professor Jiří Vohlídal. Three topics are currently being studied. The metathesis-coordination polymerization of cycloalkenes and alkynes is being investigated in close cooperation with the Institute of Macromolecular Chemistry, Czechoslovak Academy of Sciences, Prague. In cooperation with this Institute and the Department of Polymers, Institute of Chemical Technology, Prague, the colloid properties of block copolymers are being studied. Hydrodynamic degradation of polymers forms the third main area of interest of this group.

The Department of Physical Chemistry is the main organizer of the UNMACRO courses for postgraduate studies in macromolecular chemistry. These courses, directed by

Professor Vítěz Kalous which take place every second year, were started in 1972 under the sponsorship of UNESCO. The UNMACRO students stay in Prague for a year to study macromolecular chemistry and conduct research in the Department of Physical Chemistry at Charles University, the Department of Polymers at the Institute of Chemical Technology, and at the Institute of Macromolecular Chemistry of the Czechoslovak Academy of Sciences. So far about 80 students have graduated from the UNMACRO course.

Department of Polymer Physics Faculty of Mathematics and Physics

The Department of Polymer Physics, Charles University, now headed by Associate Professor Ivo Chudáček, was founded in 1973 to provide special education in polymer physics and to carry out fundamental research on this subject. Since then, about 50 M.S. and 15 Ph.D. students have graduated in polymer physics from this department.

The research activities of the department are focused on two areas: (a) polymer electronics and photophysics, and (b) mechanical and dielectric relaxation spectroscopy of polymers. The department is organized in two sections, which reflect the research orientation of the organization.

In the polymer electronics and photophysics section, headed by Associate Professor Hynek Biderman, studies of the electronic processes in polymeric systems are carried out with special attention to thin polymeric films, and the relationship between electronic properties and luminescence of polymers with molecular mobility of such polymers. In addition to the currently studied research topics of this section (consisting of Associate Professor Ivo Chudáček, Dr. Josef Klimovič, Dr. Milan Marvan, Dr. Ludvík Martínů, Dr. Danka Slavínská, and several other scientists) belongs the work on the relationship between phosphorescence and fluorescence spectra and the molecular mobility of polymeric chains. Polymers with carbazole side groups such as Poly(N-vinyl carbazole) are mainly studied. Charge transfer, quantum yield, electrical conductivity, and photoelectric characteristics in polymeric semiconductors as a function of the polymer mobility are also being studied over a wide temperature range. It has been found (by studying radio-thermo-luminescence of various polymers) that luminescence is strongly influenced by the molecular mobility of polymeric chains and of their pending side groups. Structure properties relationships of low-temperature, plasma-polymerized thin films and "diamond-like" polymers are also being investigated. Time-delay spectroscopy up to the nanosecond range and "time of flight" methods are being used in addition to the traditional spectroscopic methods.

The section on relaxation spectroscopy and polymeric structures, under the direction of Dr. Jan Nedbal, deals with viscoelastic and dielectric relaxation processes in polymeric systems, especially in model network structures based on polyisoprene, styrene-butadiene copolymers, and several other polymers. The relaxation processes are monitored over a wide frequency interval, ranging from 0.01 Hz to GHz; attention is focused mainly on processes occurring in the main transition region. The thermal depolarization and the thermally stimulated luminescence in polymers are also being investigated by this group; it consists of Associate Professor Roman Bakule, Dr. Antonín Havránek, Dr. Jaromír Fahnrich, Dr. Jiří Honskus, and several other coworkers. The influence

of low molecular additives on the viscoelastic properties as well as the effect of the crystallization behavior of polymeric systems is also being studied. Some thermoelectric and mechanoelectric phenomena have been explained and others predicted. The relaxation behavior of complex organic compounds such as DNA with special focus on the high-temperature relaxation maxima is being investigated.

TECHNICAL UNIVERSITY OF PRAGUE

Department of Material Science Faculty of Mechanical Engineering

The Department of Material Science at the Technical University of Prague, headed by Associate Professor Karel Macek, is oriented predominantly on physical metallurgy. Associate Professor Václav Zilvar with Dr. Zdeněk Kořínek and Dr. Josef Seidl form a group dealing with polymer science. They study the relations between morphology, mechanical properties and fracture mechanics of polymers and polymer composites. They are also interested in crystallinity due to mechanical stressing in semicrystalline and fiber reinforced polymers, such as in polyethylene, polypropylene and polyamide 6.

The fracture behavior of polymers and the effects of polymer structure and superstructure at various modes of stressing (creep, impact stress, dynamic fatigue) are also being studied by this group. Conditions for the formation of crazes

and the kinetics of their growth in polystyrene are also being investigated. The influence of microheterogeneous sites in the glassy matrix of polymer blends, such as in poly(2,6-dimethylphenylene oxide)-polystyrene-polybutadiene blends, on the mechanism of destruction at static or impact stressing and of fatigue is also one subject of their interest. Research on injection molding of polymer blends is also being done in relation to the structure and the fracture mechanism of polymer mixtures.

Fracture characteristics of composites based on semicrystalline polymeric matrices and glass reinforcing fibers is also being studied by light and electron scanning microscopy. Wide-angle X-ray scattering, dynamic calorimetry (DSC) and densitometry are used for observing and evaluating the supermolecular structure of polymers.

INSTITUTE OF CHEMICAL TECHNOLOGY PARDUBICE

Department of Technology of Macromolecular Materials

In 1951, the Institute of Chemical Technology was established in Pardubice in Eastern Bohemia, an industrial town with a population of about 95,000. The Department of Plastics, later renamed the Department of Technology of Macromolecular Materials, was initially headed by Professor Josef Rožan, later by Professors Jaromír Weigner, Karel Friml, and Josef Mležíva. Since 1986, the department has been under the direction of Associate Professor Jaroslav Jaružek. Until now, more than 600 M.S. and about 60 Ph.D. students of polymer science and technology have graduated from the Institute of Chemical Technology in Pardubice.

The research activity of the Department of Technology of Macromolecular Materials is focused on two major areas: reactive polymers and paints and coatings materials.

Professor Josef Mležíva with his group is studying the relationship between processing conditions and the properties of polymeric systems with special emphasis on epoxy resins. The effect of resin modification, use of reactive sol-



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Institute of Chemical Technology, Pardubice

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vents and various curing systems are being evaluated with the aim of preparing novel engineering materials with improved properties.

Dr. M. Večeřa's research group is concerned with the synthesis of thirane analogs of epoxy resins and is studying their properties.

Associate Professor V. Liška with his group deals with chemorheology of reactive polymeric systems mainly based on epoxies.

Associate Professor V. Čermák and his research team is concerned with the study of UV-crosslinking of acrylic polymers. The kinetics of the reactions involved in photo-initiated crosslinking is being carefully investigated. This group is also engaged in the development and the application of various techniques of UV-curing of protective coating based on acrylics.

Associate Professor Jaroslav Jarušek with Dr. R. Milič and his group are interested in the preparation of novel anticorrosive paints and coatings with new types of plasticizers and pigments. The research interests of this group involve also problems of measuring the corrosion rate, the diffusion of acids through polymeric coating and other applied projects.

Department of Chemical Technology of Fibrous Materials

Research in the Department of Chemical Technology and Fibrous Materials is focused on the preparation and the study of the properties of new types of fibers and fiber-forming polymers, textile materials and organic dyes. The department is headed by Associate Professor Jaroslav Růžička. His research interests include modification of polypropylene fibers for improved coloring and photostability, synthesis of high-molecular additives for polyolefins with combined activities, preparation of monomers and precursors of high performance fibers, synthesis of biodegradable polymers for biomedical applications, and the development of special products for textile and fiber treatment.

Dr. Ladislav Kudláček with his group is involved with the preparation of regenerated cellulose fibers from cellulose solutions. The preparation and properties of multicomponent polymer fibers are also the subject of his interest. New methods for observing the formation of supermolecular structure in various periods of the spinning process are also being developed.

Associate Professor Josef Píkrýl with Dr. Marie Kaplanová are interested in transport processes of organic species in polymers with special attention on diffusion processes involving organic dyes. Optical microdensitometry, photoacoustic spectrophotometry, fluorescence spectrophotometry, low-angle light scattering, electron and optical microscopy are the main experimental methods employed for the study of the structure and properties of fibers and for observing processes proceeding the fibers preparation.

TECHNICAL UNIVERSITY OF BRNO

Department of Rubber and Plastics Technology Faculty of Technology with the seat in Gottwaldov

Gottwaldov, formerly Zlín, is a center of rubber, plastics and footwear industries in Czechoslovakia. It is a town with population of about 70,000 located in Southern Moravia, approximately 65 km east of Brno. In Gottwaldov, the Batá shoe-making company was started at the beginning of this century; many polymer processing enterprises are now located in Gottwaldov and its vicinity (e.g., Svit, Gottwaldov; Fata, Napajedla; Rudý Říjen, Otrokovice). The research Institute of Rubber and Plastics Technology, the biggest Czechoslovak industrial research institute of applied polymer research is also located in Gottwaldov.

In 1969, the Faculty of Technology of the Technical University of Brno was established in Gottwaldov to prepare university graduates for leathermaking, for the rubber and plastics industries, with special attention to process engineering of natural and synthetic polymers. The Department of Rubber and Plastics Technology was initially headed by Associated Professor František Tomis and since 1986 the department has been headed by Associated Professor Josef Klásek.

The main research activity of the Department consists of solving technological and engineering problems of rubber and plastics processing. But fundamental research activity are also going on in polymer science in two major areas: (a) structure/property relationship of polymeric composites, and (b) fundamentals of polymer processing.

Associate Professor František Rybníkař is interested in studying the morphology and structure of filled poly-



Faculty of Technology Gottwaldov

olefins and modeling the deformation and fracture behavior of composites.

Associate Professor Josef Špaček is dealing with dispersing particulate fillers, such as carbon black, in elastomeric matrices. He is studying the relationships between the dispersion level and the properties of the filled elastomers.

Associate Professor Antonín Klásek is coordinating research activities in the field of polymer modification and processing. His personal research interest is the preparation of polymeric liquid crystals based on aromatic polyesters and the investigation of their properties.

Dr. Karel Stoklasa, Dr. Petr Saha and Associate Professor Vladimír Klepal are interested in studying and modeling the process of extrusion of polymeric materials by using applied rheology.

Dr. Zdeněk Zámorský has been interested in the chemical modification of polyolefins, such as grafting during the processing of polymers. He is also interested in processes involved in polyolefin aging and polymer degradation.

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