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The German Democratic Republic (GDR), a country of about 17 million inhabitants, shares a border in the east with Poland, in the south with Czechoslovakia, in the west with the Federal Republic of Germany (FDR), and is bordered in the north by the Baltic Sea. The GDR has excellent teaching and research institutions and a well-developed polymer-producing and -processing industry with a long tradition. Even during the first decade of this century, polymers were produced in Germany in locations which are now a part of the GDR. Scientists of the industry in the GDR are trained in the universities and technical institutions of this country; great emphasis is placed on the close interdependence of teaching, research, and application. As a consequence, the centers of education, particularly the seven leading universities of the GDR, have become effective research institutions; polymer science is taught in various departments of almost all the universities. It should be mentioned that the universities and the individual branches of the chemical industry also cooperate with the Institutes of the Academy of Sciences, where research is also being carried out. Several leading personalities of the Academy Institutes have professorial rank, and graduate research is pursued under their supervision, usually at the Academy Institutes. In other cases, academic degrees are granted by university institutes while the scientific work is actually done in the research institutes of the Academy of Science. A number of universities which are important centers for teaching and research in polymer science and technology, also interact closely with industry. Polymer scientists are trained in chemistry, physics, and material science at the universities, receiving general training in their respective scientific disciplines as well as in basic polymer science, and also gain specialized experience in the production, processing, and application of polymers.

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Technical University "Carl Schorlemmer" Leuna-Merseburg

Perhaps the most important and comprehensive teaching and research institution for polymer science in the GDR is the Technical University "Carl Schorlemmer" of Leuna-Merseburg, which is located in Merseburg, between the two largest industrial chemical companies, Leuna and Buna. These complexes were formerly part of the German I. G. Farben industry.

At the University of Leuna-Merseburg, the departments of chemistry, physics, and material science include polymer science in their curricula. Consequently, research is carried out in many aspects of macromolecular science and engineering, including the synthesis and characterizations of macromolecules and the physical properties, processing, and applications of polymers.

One of the major research efforts in polymer research is in the development of a theoretical treatment called continuous thermodynamics; this research by Professor Margit T. Raetzsch, the President of the University, has as its major thrust, the application to polymeric systems. It has been shown that it is possible to overcome the existing inconsistency between discontinuous thermodynamics and the experimental continuous distribution functions; it was found that in polymeric systems this inconsistency can most convincingly be overcome. Turbidity, shadow and con-

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sistency curves as well as distribution functions of homo- and copolymers and polymer mixtures can be predetermined and estimated. A particularly striking system wherein continuous thermodynamics is very effective is the system of ethylene and polyethylene under high pressure.

Synthesis of macromolecules is another important branch of polymer science at this university. Under the direction of Professor J. Ulbricht, research is being carried out on macromolecular architecture; his group is studying the effect of the structure of organometallic coordination initiating systems on the stereoregularity in olefin and diene polymerizations, using these initiating systems, maximizing their activity, and detecting the reasons for the deactivation of highly active, supported initiating systems.

Block copolymers are also prepared from various comonomers using different polymerization techniques; this work also makes possible the preparation of new polymers with new combinations of properties.

Special attention is given to the preparation and characterization of crosslinked polymers. The mechanism of epoxide and butadiene formation and the preparation of prepolymers is being studied; the crosslinking reactions are ultimately carried out with the help of photochemical procedures. New methods are also developed for the quantitative investigation of crosslinking processes by this technique; the network polymers obtained by this method are being characterized.

In the section of theoretical physics, the theory for the preparation and behavior of polymer networks is being developed. Research is carried out on the dynamics of polymer systems, which involves both the theoretical description and the experimental determination of polymer mobility. The theoretical understanding of network polymers is also compared with the actual properties of polymeric materials, not only from the phenomenological but also from a molecular-statistical point of view. A wide variety of methods are now available for experimental investigations, some of which are further developed as new apparatus for polymer characterizations become available. Extensive investigations are also being carried out on the structure of modified polymers, co- and terpolymers, graft and block copolymers, polymer networks, polymer blends, filled and reinforced polymers. The structure/property relationship, based on the molecular structure and the micro- and macrodynamic behavior is also being investigated. Physical methods are used extensively for studying the formation and growth of

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polymer particles in polymerization processes, in particular the phase behavior, molecular interaction, and interface phenomena.

Research on materials technology is concerned with the phase morphology of semicrystalline and multiphase polymer systems, their effect on the properties of polymers and their long-term behavior. The morphology of polymers and blends during preparation and the changes which take place during processing are being studied. The mechanical properties of polymers reinforced with short fibers are being investigated. Mathematical models are being developed which make it possible to predetermine the elasticity module, the thermal expansion, and the swelling behavior of these polymeric systems, and to predict for industrial production the optimum condition for the addition of reinforced polymers. Investigations of polymer melts and solution properties on a broad base serve as a basis for the modeling of fabrication processes, such as extrusion, film blowing, and compounding. These methods can be used for the optimization of the production, the consistency of the process, and the product quality.

In the Chemistry Section of the Technical University of Dresden there is a considerable amount of activity in teaching and research in polymer science (Professor Werner Berger). Special emphasis in polymer chemistry and polymer physics is given to textile chemistry. Polymer synthesis is concerned with the preparation of specialty polymers using ionic and radical polymerizations and the chemical modifications of polymers. Polymer technology laboratories in Dresden are also involved in the development of unusual physical and mechanical properties of polymer blends. Much work is also done on the characterization of polymers, particularly the determination of molecular weight and polydispersivity of copolymers using chromatographic methods (Professor Glockner). A very substantial effort in the research group of Professor Berger is devoted to the development of solvents and solvent systems for normally insoluble polymers. In the cellulose area, the group is interested in the processing of cellulose from solution without the use of carbon disulfide (viscose process). Various cyclic amide solvents, with and without additives, were found to be very effective.

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Optimization of dyeing and refining procedures for various fibers is also being investigated. In coopperation with other research teams, spectroscopic and radiochemical methods are used to determine the position of the dye in the fibers and to determine the mechanism of the dyeing processes in the various systems.

The Industrial Chemistry Section deals with technological problems and the applications of mathematical modeling of the systems (Professor Winfried Pippel). Within the Technical University of Dresden, the various disciplines of polymer science are being pursued in the departments of mathematics, physics, electrical engineering, material science, and microelectronics, all working closely together.

A third important university in which polymer science teaching and research are carried out is the Friedrich Schiller University in Jena. In the Department of Chemistry, at least three research teams are concerned with various aspects of polymer synthesis. One research group (Professor Guenther Heublein) is involved with research on ionic polymerization reactions, particularly the cationic polymerization of vinyl monomers and dienes, not only in the preparation of polymers but also in the theoretical explanation of cationic polymerization. Spectroscopy, calorimetry, and conductivity measurements are used to determine quantitatively the relationship between chain propagation and the limitation of

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Friedrich Schiller University Jena

the chain reaction polymerization. For monomers of high electron density, for example vinylethers, the polymerization was achieved without chain transfer—first by monomer solvation and by the stabilization of the counterions with specially prepared acceptors and secondly by an orbital-controlled interaction of the anion with the growing cation. For the cationic homocopolymerization of substituted styrenes, a quantitative understanding of the polymerization could be worked out by multiparameter equations according to the principle of polylinearity. The group has also developed a new method for determining dynamic copolymerization parameters which are connected with the calculation of "individual rate constants" and permits the quantitative determination of the relative reactivities of monomers as the conversions increase.

Theoretical investigations also serve as the basis for the novel concept of selective polymerization of dienes and olefins from industrial pyrolysis fractions. Selective polymerization has become an important new process for the synthesis of conventional and new polymers. In addition, radical copolymerization is also used for select polymerization, particularly the radical copolymerization involving vinyl acetate which can now be carefully controlled.

The preparation of functional polymers with covalently bound pesticides and antimicrobically active agents are also

being studied in Jena (Professor Manfred Hartmann). This work on biologically and pharmaceutically active polymers with controlled activity adds to the general knowledge of the relationship between polymer structures and the properties and performance of such polymers. It involved the development of new delivery systems for biologically active agents as well as new delivery systems for agricultural applications. Selected biocides have been reversibly linked to polymers as pendent groups, either directly or with a spacer group, or have been incorporated into polymer chains by different hydrolytically and enzymatically labile bonds. As carriers of these biologically active agents, naturally occurring polymers and various synthetic oligomers and polymers with hydroxyl and carboxyl groups as the functional groups are used. After the biologically active group is attached to the polymers, hydrolysis studies under various conditions have been carried out. Bioassays are being taken, and controlled release behavior of most of the synthetic polymers have been demonstrated. To tailor-make polymers with variable release rates, research is presently conducted with the aim of preparing polymers with various types of solubility and with increased stability. Agricultural chemicals are studied for specific applications as well as for application where the normal type of application would be detrimental to the environment.

Specialty polymers are being studied extensively by the group of Professor Horhold, especially aromatic polymers such as polyarylene vinylenes, which exhibit photoconductivity and a high, dark resistance. A model for the conjugation and efficient segment length has been developed for these polymers. Professor Horbold's group is also interested in the synthesis of soluble and thermoplastic high molecular weight polymers from epoxides and amines. The reaction mechanism and the structure/property relationship of these polymers are being investigated.

At the Karl Marx University of Leipzig a research team in the physics department under Professor Ruscher is concerned with the determination of various polymer properties, for example by radio-frequency spectroscopy. This group is also investigating the theories of molecular displacements, details of the microstructure of homo- and copolymers in the solid state, molecular mobility of polymers in solutions, and polymer structures analyzed by quasi-elastic light scattering or by NMR spectroscopy. EPR spectroscopy is used to follow radical polymerization in the liquid state, covering especially the investigation of short-lived radicals in the initial phase of homo- and copolymerization. This method provides information for the elementary process of radical formation and chain propagation.

At the Martin Luther University of Halle, there is also a research group working in the field of polymer chemistry. This group is involved primarily in the study of functional and cross-linked polymers and their use as ion exchange resins; other types of active resins for absorption methods and those that can serve as reactive resins are also being studied. The synthesis of these polymers, their physical chemical properties and their industrial applications are under investigation.

Coordination polymerization of dienes is being investigated at the Ernst Moritz Arndt University of Greifswald. The research group there is studying the relationships between the structure of the coordination initiators and the coordination sites and the structure of the polymers formed. Secondary and side reactions which occur during the coordination polymerization are also studied.

Although there are other important universities in the GDR such as the Humbolt University of Berlin, the universities in Rostock, Erfurt, Magdeburg, and Freyberg, to mention only a few, not much actual polymer work is being carried out at these institutions although biological macromolecules are being investigated.