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MACROMOLECULAR NEWS

MIDLAND RESEARCH CENTER DEDICATED

A unique, privately funded research organization was formally dedicated on September 28-30, 1972, in Midland, Michigan. Named the Midland Macromolecular Institute (MMI), the facility houses scientists involved in "pure" or basic research on substances having high molecular weight (e.g., plastics, fibers, and biopolymers).

About 400 scientists from industry and education attended the ceremonies, as well as interested nonscientific members of the community. The scientists came from 22 states, the District of Columbia, England, Japan, Germany, and Canada. They represented 51 colleges and universities and 27 industrial firms.

The three-day event included a dedication on Thursday, a scientific symposium on Friday, and an open house on Saturday.

The dedication began at 2 p.m. Thursday at the Midland Center for the Arts with chamber music featuring the Cleveland Quartet. The principal speaker was Dr. Paul J. Flory, chairman of the Department of Chemistry at Stanford University, who spoke on "The Challenge to Macromolecular Science." Others speaking at the dedication were H. D. Doan, president of the Michigan Foundation for Advanced Research which funds MMI; Dr. Melvin Calvin, director of the Laboratory of Chemical Biodynamics at the University of California, Berkeley, and a Nobel Prize winner in chemistry; Dr. H.-G. Elias, director of MMI; and Dr. Charles Overberger, vice president for research at the University of Michigan.

Following the dedication, guests toured the MMI facilities. In the evening, Dr. Herman Mark, dean emeritus at Polytechnic Institute of Brooklyn, was the keynote speaker at a dinner dance for invited guests at the Midland Country Club.

On Friday MMI sponsored its first scientific symposium at the Midland Center for the Arts. Six speakers presented papers on "Trends in Macromolecular Science:"

"Organic Chemistry of Macromolecules" by Dr. Overberger.

"Biopolymers: Origins, Chemistry and Biology" by Dr. Calvin.

"Polymers in Medicine" by Dr. D. J. Lyman, professor of material science in the College of Engineering and associate research professor of surgery at University of Utah.

"Spatial Configuration of Macromolecules" by Dr. Flory.

"Structure/Property Relationships in Polymers" by Dr. E. H. Andrews, professor and head of the Department of Materials, Queen Mary College, University of London.

"Processing and Fabrication of Polymers" by Dr. Turner Alfrey, research scientist in the Physical Research Laboratory, Dow Chemical U.S.A.

On Saturday MMI held an open house for the public.

Facts about the Midland Macromolecular Institute

MMI is a division of the Michigan Foundation for Advanced Research, a privately funded, nonprofit organization founded in 1964 by three Midland-based private foundations: the Herbert H. and Grace A. Dow Foundation, the Rollin M. Gerstacker Foundation, and the Charles J. Strosacker Foundation.

MMI is a laboratory devoted to basic research and study in the field of macromolecular science. MMI scientists conduct basic research on the physics and physical chemistry of substances made up of chains of long molecules (having high molecular weight) whether synthetic (like nylon), natural (like cotton, silk, wood, or wool), or biological (like enzymes or skin tissue).

Ground was broken for the MMI building in the spring of 1970. The $1.7 million facility was completed in July 1971. It is a tri-level building with laboratories, offices, and two libraries on the upper levels and mechanical utilities on the lowest level. The building has 13 laboratories of 1000 square feet. Each pair of laboratory modules shares a hood and office for three postdoctoral workers. There are 14 offices for the administration and senior scientists, a 99-seat lecture hall, a seminar room with 20 seats, a conference room seating 12, a work room, a computer center, a shop/storage area, a recreation room/cafeteria, and a four-room apartment for a visiting scientist.

MMI is part of Midland's "creative center" which also includes the Midland Center for the Arts, the Grace A. Dow Memorial Library, and the Dow Gardens. All of the buildings were designed by Midland architect Alden B. Dow.

MMI operates on a $500,000 annual budget granted by the Michigan Foundation for Advanced Research for 9 years. There is no obligation with respect to how the money is used or the specific type of research done. MMI is independent of universities, industry, and government, though it is hoped that additional financial support will come from these groups as well as other foundations.

MMI is free to conduct original research alone or in collaboration with industry or educational institutions or governmental agencies. MMI will engage in contract research for industry or government only

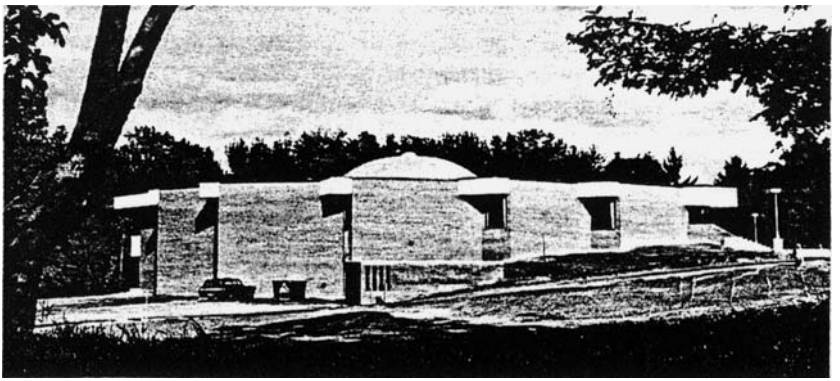

FIG. 1. The Midland Macromolecular Institute facilities include laboratories, lecture rooms, administrative offices, and technical libraries. Operating on a $500,000 annual budget, MMI scientists study substances made up of chains of long molecules, whether synthetic (like nylon), natural (like wood), or biological (like skin tissue).

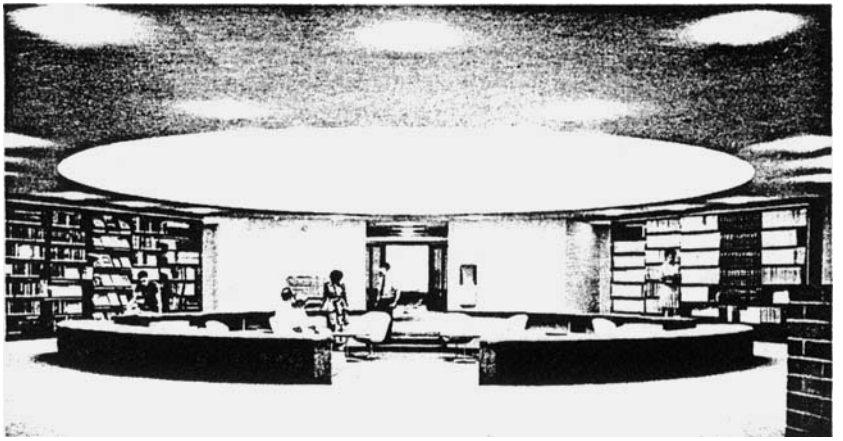

FIG. 2. Staff members at the Midland Macromolecular Institute gather in the building's central lounge and library for conversation and to look up resource information.

if the results can be made public within a limited number of years.

Dr. Hans-Georg Elias is director of MMI. The current staff consists of three permanent scientific staff members, six postdoctoral workers, and an administrative and technical group of six persons. The budget permits a staff of four senior scientists, 10 postdoctoral workers, and seven administrative and technical workers.

MMI educational activities include the following:

1. An undergraduate level course, "Introduction to Macromolecular Science," which it is hoped will be accredited by area colleges. The course will be offered beginning in the winter of 1972.
2. Informal seminars covering all aspects of macromolecular science for MMI staff members and a limited number of invited industrial scientists. The topics require previous knowledge of macromolecules. The first seminar was held in March 1972.
3. Seminars by MMI staff members on completed but unpublished research work. These meetings are intended to acquaint the local scientific community with the activities of MMI. The first seminar was held in January 1972.
4. Lectures by guest speakers. Twelve speakers from the United States, Japan, The Netherlands, France, and England have lectured at MMI so far this year.

MMI will sponsor or cosponsor in Midland one or two scientific symposia each year. The proceedings will be published in a "Midland Macromolecular Meetings" series. The first volume of the series will contain lectures given at the dedication of MMI. The second symposium will be in August 1973 on "Order in Polymer Solutions."

A visiting professorship at MMI has been set up through the joint efforts of the Midland section of the American Chemical Society, Central Michigan University, Michigan State University, Saginaw Valley College, The Dow Chemical Company, Dow Corning Corporation, and MMI. The visiting professor is to give a 3-week course at MMI on a subject of mutual interest to the participating organizations.

Background on Macromolecules

Most structures in nature are high polymers. Such common natural substances as wood, cotton, wool, silk, hair, skin, muscle, tissue, natural rubber—all are high polymers. And they all have two things in common. All are made up of chains of long molecules and all are of high molecular weight. All are macromolecules.

Other common substances in nature such as water, oil and gasoline, alcohol, nitrogen, paraffin—these are of shorter chain structure and low molecular weight.

For approximately 200 years, scientists have concentrated their study on low molecular weight substances. Much is known about them —how they are made in nature, what reaction they will have when treated or changed in some way.

Man doesn't know as much about the high molecular substances. Scientists have been studying them systematically for about 40 years. A great deal is known about macromolecular materials, but compared with low molecular weight substances, the store of knowledge is small.

Many of the techniques and tools developed and used by science have been designed primarily for substances of low molecular weight. High polymer research has been hampered because many of these tools and techniques do not fit high polymer research. MMI will work to contribute new tools and techniques—new methods of study for unlocking the secrets of high polymers.

In addition to the high polymers found in nature, man has developed an abundant and varied family of synthetic materials. One of the first and most famous, even today, is nylon. Another early success was neoprene or artificial rubber. Work has continued in this area and recently artificial rubber with identical properties to natural rubber was developed. In laboratory analysis the natural and artificial material are identical.

MMI will work to increase man's knowledge of these kinds of substances.

Staff of Midland Macromolecular Institute

Director

Dr. Hans-Georg Elias was educated at the Munich Institute of Technology and the Hannover Institute of Technology in Germany. Prior to joining MMI in 1971 he was associate professor of macromolecular chemistry with the Swiss Federal Institute of Technology in Zurich. He has authored about 130 papers and two books and has served as consultant to more than a score of industrial companies in Western Europe and the United States. He is associate editor of two international scientific journals.

Senior Research Scientists (equivalent to full professor)

Dr. Dale J. Meier was with Shell Chemical Co. from 1951 to 1971, most recently as supervisor of research. He received his bachelor's and master's degrees from California Institute of Technology and his Ph.D. from the University of California at Los Angeles in 1951. He has about 20 papers and patents to his credit.

Dr. Robert L. Miller was with Monsanto Company from 1953 to 1971. His last assignment with the company was as a science fellow with the Central Research Department. In 1968 he was a senior visiting scholar at Manchester University in England. He received his bachelor's degree from the Massachusetts Institute of Technology in 1950 and a Ph.D. from Brown University in 1954. He is the author of 32 publications.

Research Scientist (equivalent to associate professor)

Dr. Karel Šolc was a research associate and lecturer at Dartmouth College from 1968 to 1971. Before that he was research scientist and head of a laboratory at the Institute of Macromolecular Chemistry, Prague, Czechoslovakia, for 7 years. He was educated at the Institute of Chemical Technology, Prague, and the Czechoslovak Academy of Sciences, Prague, where he obtained the equivalent of a Ph.D. in 1961. He has published 23 papers in his field.

Research Associates (postdoctoral fellows)

Dr. Mary M. Exner was a research chemist with The Dow Chemical Company from 1968 to 1971. She was graduated from Mount Holyoke College in Massachusetts with an A.B. degree and received her Ph.D. from the University of Washington at Seattle in 1968.

Dr. Stuart J. Gaumer was a research physicist with Owens-Illinois from 1971 to 1972. After receiving his bachelor's degree in physics from Michigan State University in 1961 he worked for The Dow Chemical Company for 5 years. He then returned to MSU to work toward a Ph.D. which he received in 1972.

Dr. William Gobush was a postdoctoral fellow at Texas A&M University before joining MMI. He received an A.B. degree from Clark University in Worcester, Massachusetts, in 1966 and a Ph.D. from Dartmouth College in 1970.

Dr. Hsueh-Ming Li was a postdoctoral fellow at Polytechnic Institute of Brooklyn before joining MMI. He received a bachelor of science degree from Tunghai University in Taiwan in 1962, a master of science from Southern Methodist University at Dallas in 1966, and a Ph.D. from Polytechnic Institute of Brooklyn in 1971.

Dr. John Semen joined MMI after receiving his Ph.D. from Case Western Reserve University this year. Following graduation from Newark College of Engineering in 1966, he was a research trainee with Union Carbide. He then returned to school and received his master's degree from Case in 1969.

Dr. John A. Valicenti was a chemist with Dow Corning Corporation for 6 years before joining MMI in 1971. He was graduated from the University of Notre Dame with a bachelor's degree in 1961 and from Wayne State University with a Ph.D. in 1965.

Participants at the Dedication Ceremonies of Midland Macromolecular Institute (All Events)

Affiliation	Participants[a]	Spouses	Total
Government	6	4	10
Universities and Colleges			
Officials	10	4	14
Professors	79	40	119
Other Scientific Institutions			
MMI	14	11	25
Other	2	1	3
Industry			
Dow Chemical	165	18	183
Dow Corning	76	9	85
Other	35	14	49
Foundations	8	7	15
Press	6	1	7
Other	11	0	11
Total	412	109	521

[a]Included are 72 university and college professors; 9 presidents, vice presidents, and other university and college officials; 10 presidents and vice presidents of chemical companies; and 8 presidents or directors of foundations or independent institutions.

Universities, Colleges and Scientific Institutions Represented at MMI Dedication Ceremonies

Alma College, Alma, Michigan
Baylor University, Waco, Texas
California Institute of Technology, Pasadena, California
Carnegie-Mellon University, Pittsburgh, Pennsylvania
Case Western Reserve University, Cleveland, Ohio
Central Michigan University, Mount Pleasant, Michigan
Clarkson College of Technology, Potsdam, New York
Delta College, University Center, Michigan
Eastern Michigan University, Ypsilanti, Michigan
Florida State University, Tallahassee, Florida
Illinois Institute of Technology, Chicago, Illinois

Kent State University, Kent, Ohio
Kyoto University, Japan
Lehigh University, Bethlehem, Pennsylvania
McGill University, Montreal, Canada
Massachusetts Institute of Technology, Cambridge, Massachusetts
Michigan State University, East Lansing, Michigan
Michigan Technological University, Houghton, Michigan
North Carolina State University, Raleigh, North Carolina
Northern Michigan University, Marquette, Michigan
Northwestern University, Evanston, Illinois
Northwood Institute, Midland, Michigan
Polytechnic Institute of Brooklyn, New York, New York
Queen Mary College, University of London, London, England
Rensselaer Polytechnic Institute, Troy, New York
Research Triangle Institute, Durham, North Carolina
Rutgers University, New Brunswick, New Jersey
Saginaw Valley College, Saginaw, Michigan
Stanford University, Palo Alto, California
State University of New York at Albany, New York
State University of New York, College of Forestry at Syracuse, New York
Syracuse University, Syracuse, New York
University of Akron, Akron, Ohio
University of California at Berkeley, California
University of Connecticut, Storrs, Connecticut
University of Dayton, Dayton, Ohio
University of Detroit, Detroit, Michigan
University of Florida, Gainsville, Florida
University of Iowa, Iowa City, Iowa
University of Maryland, College Park, Maryland
University of Massachusetts, Amherst, Massachusetts
University of Michigan, Ann Arbor, Michigan
University of North Carolina, Chapel Hill, North Carolina
University of Notre Dame, Notre Dame, Indiana
University of Pennsylvania, Philadelphia, Pennsylvania
University of Utah, Salt Lake City, Utah
University of Waterloo, Waterloo, Ontario, Canada
University of Wisconsin, Madison, Wisconsin
Washington University, St. Louis, Missouri
Wayne State University, Detroit, Michigan
Western Michigan University, Kalamazoo, Michigan

Industrial Companies Represented at MMI Dedication Ceremonies

Air Products Corp., Allentown, Pennsylvania
Allied Chemical Corporation, Morristown, New Jersey

Amoco Chemicals Corp., Naperville, Illinois
Asahi-Dow Co., Springfield, Massachusetts
Baker Perkins Inc., Saginaw, Michigan
BASF Wyandotte, Parsippany, New Jersey
Beckman Instruments, Southfield, Michigan
Boeing Co., Seattle, Washington
Ciba-Geigy, Ardsley, New York
Dow Badische Co., Williamsburg, Virginia
The Dow Chemical Company, Midland, Michigan
Dow Corning Corporation, Midland, Michigan
Duralastic Products Corp., Detroit, Michigan
Firestone Tire and Rubber Co., Akron, Ohio
Ford Motor Co., Dearborn, Michigan
General Electric, Schenectady, New York
General Motors Corp., Warren, Michigan
General Tire & Rubber Co., Akron, Ohio
B. F. Goodrich Chemical Co., Brecksville, Ohio
B. F. Goodrich Chemical Co., Cleveland, Ohio
Monsanto Co., Durham, North Carolina
NL Industries, Hightstown, New Jersey
Owens-Illinois, Okemos, Michigan
Phillips Petroleum Co., Bartlesville, Oklahoma
PPG Industries, Pittsburgh, Pennsylvania
Stauffer Chemical Co., Dobbs Ferry, New York
Tennessee Eastman Chemical Co., Kingsport, Tennessee

Poly(α-amino acids)

H. G. Buehrer, H.-G. Elias, M. Exner, and J. Semen

α-Amino acids are the building units of all proteins, naturally occurring macromolecules. The large family of proteins includes macromolecular catalysts such as the enzymes on the one hand, and fiber-forming macromolecules like silk and wool on the other. Proteins can be considered as copolymers of α-amino acids, i.e., they are composed of many different types of α-amino acids (usually up to 20 different amino acids in varying proportions per molecule). Proteins are thus very complicated macromolecules. Many characteristic features of the copolymers are nevertheless retained in the simpler analogs made up from just one type of α-amino acid. These contain many α-amino residues of the same type per molecule and are called homopolymers. The homopolymers may serve as models for the study of proteins. Depending on the α-amino acid used to form the homopolymer, biodegradable films or fibers may be made. Such a poly(α-amino acid) is already commercialized in Japan for the production of synthetic leather. Leather itself is another type of protein.

At present MMI is studying the synthesis of poly(α-amino acids). Whereas most of the α-amino acids in nature occur in one form, the so-called L-isomer man-made α-amino acids are in general mixtures of two forms, L- and D-isomers, which are difficult to separate by physical methods. Normal polymerization of these mixtures leads to copolymers with both L- and D-units in the molecules. It is known, however, that useful properties of poly(α-amino acids) can be achieved only if the macromolecule is predominantly composed of one isomer. Recent work at MMI has shown that a partial separation of the L- and D-mixture may be achieved by the choice of suitable catalysts for the polymerization of these L- and D-isomers without their prior physical separation. MMI is at present studying this polymerization process as well as other ones. The work will shed light on the nature and the control of the so-called asymmetric synthesis and on the properties of poly(α-amino acids).

Polymerizable Detergents

H.-G. Elias and J. Valicenti

Detergent molecules form, in water at sufficiently high concentrations, associates (physical polymers) of many molecules, so-called micelles. The structure of micelles undoubtedly influences their properties. The properties of micelles have been utilized in washing processes, as drilling agents in the petroleum industry, and as emulsifiers in polymerization processes leading to the manufacture of plastics and rubbers. Little is known, however, about the physical structure and shape of micelles as a function of the chemical structure of the detergent molecules.

Earlier studies of the Elias group have indicated that some detergents may form micelles with a water core. This structure proposal is based on indirect measurements. MMI is now attempting to synthesize polymerizable detergents with the hope of fixing the micelle structure via polymerization. If successful, the shape of the micelle can then be studied by electron microscopy and other methods. In addition to presenting a possible direct method for the study of micelle shape and structure, the investigation should give information on the polymerization in pre-ordered structures, a little studied but very important field.

Transitions and Relaxation Phenomena in Polymers

R. F. Boyer,* H.-G. Elias, and S. Gaumer

Macromolecular materials such as plastics, elastomers, resins, and fibers are very different in their behavior than are metals. Their

*The Dow Chemical Company.

thermal expansion is larger and differs appreciably between characteristic temperatures. One of these temperatures is the so-called glass temperature or glass transition temperature. Below this temperature, a material behaves like a brittle glass; above it, like a rubber. The thermal expansion coefficient is low below the glass temperature and large above it. Many other transition temperatures are known to exist in noncrystalline polymers. All of them influence the mechanical properties of the material.

The transition temperatures are correlated with the onset of different types of molecular motion. The physics of these motions is not yet well understood. MMI has thus started an investigation of the thermal expansion at low temperatures. The measurements will lead to useful engineering data and at the same time will provide a firmer basis for elucidating the influence of chemical and physical structure on these transitions and on the physical properties of the material.

Sickle Cell Anemia

R. L. Miller

Sickle cell anemia is a particularly crippling disease affecting persons (mainly black) who have a certain genetic defect in the hemoglobin molecules within their red blood cells. Hemoglobin is a protein macromolecule, and the genetic defect which permits sickling is the change of one of the α-amino acid units (the sixth) to another. According to hypothesis, this change in chemical structure of the macromolecule leads to a slight change in the conformation (shape) of the hemoglobin molecule. In turn, this change in shape permits hemoglobin molecules to fit and lock together, in a building-block fashion, to form fibrous "super-macromolecules" whose flow through the blood vessels is restricted, hence causing a sickling crisis. Recent discoveries by a group at Blodgett Hospital, Grand Rapids, and Wayne State University, Detroit, have shown the effectiveness of large doses of the simple chemical, urea, in reversing and/or preventing sickling. This appears to be the first time that a molecular—rather than chemical or biological—approach to the treatment of a disease has been effective. The success here immediately raises the question of what other diseases may be treated so simply (and safely).

MMI studies, in collaboration with the above-named group, will aid in demonstrating the correctness of the assumed sickling mechanism and will try to determine the basis for the success of the urea treatment. Progress in these studies should lead to improved treatment of sickle cell anemia and should indicate approaches to other diseases which can be treated analogously.

Solid State Polymer Structure and Properties

H. M. Li and R. L. Miller

As solids, polymers (both naturally occurring and synthetic) adopt many complicated levels of structure. These levels, in many ways, are analogous to the structural levels which exist in a civilization. With humans, one has the family unit as the smallest level of organization. This is followed by the collection of families in towns, cities, counties, states, etc. So also in polymers, one has the collection of small, simple units (monomers) into a single polymer chain (through the process of polymerization). Polymer chains, in turn, aggregate to form higher structural levels, such as glasses or crystals. Crystals, in turn, aggregate to form units called spherulites or fibrils, which in turn aggregate to fill the volume of the sample under consideration. The useful properties of the final product are determined largely by the kind of structural levels present within the product and the amount of each level. That is, properties are determined by the details of the structure present. These details, in turn, are set by the thermal and mechanical history of the product up to the point of test of the property.

The relationships between properties, structure, and history are only partly understood at present. MMI studies will continue an exploration of these relationships with the goal of permitting more direct specification of the requirements (chemical, thermal, mechanical) to obtain a specific property. Of particular interest in the immediate future is the study of the structural details which result when a material is permitted to crystallize (cool) while under the influence of external restraints, such as orientation. Such conditions simulate many macromolecular processes both natural (such as growth of trees) and synthetic (such as spinning of fibers).

Shape of Flexible Polymer Molecules

K. Šolc and W. Gobush

Both in the plastics industry and basic research, it is important to understand the relation between the molecular structure of a plastic (or, more generally, of a polymer) and its physically observed properties. In order to get closer to this remote goal, scientists have been setting up models for polymer molecules, calculating how such models behave under different conditions, and comparing the results with experimental observations. Mostly the agreement can be only as good as the model is—therefore much effort has been devoted to a better description of polymer molecules. Unfortunately

this is not simple: a polymer molecule is not rigid, but looks rather like a ball of woolen thread which sometimes is squeezed tighter, sometimes is looser, and takes many different shapes. Whereas the size of a polymer molecule has been studied extensively, there is almost no information available on its different shapes.

Recent work done at MMI has shown, to the great surprise of some scientists, that the linear polymer molecules are mostly greatly nonspherical, looking far more like a cake of soap than like a tennis ball. The dependence of shape on the structure and the environment of the polymer molecule has also been studied. It has been shown that a nonspherical model of polymer molecules is in better agreement with osmotic pressure data than the commonly used spherical model. We are presently trying to apply the nonspherical model to other properties which depend on shape.

Heterogeneous Polymers

D. J. Meier

The usefulness of metals increased enormously when it was discovered long ago that mixtures of different metals (alloys) offered properties that were unobtainable in a pure metal. Within the relatively recent past, similar observations have been made with polymers. Although most polymers are incompatible with one another, this incompatibility can be advantageous, and certain polymer "alloys" have properties that are greatly improved over the pure component polymers. Several of these types of polymers have become important commercial materials. It is likely that most of the important advances that will be made in developing new useful polymers will depend upon the use of heterogeneous polymer, produced either by the blending of different polymers or by sophisticated polymerization methods.

Although the trend toward heterogeneous polymers can be foreseen, progress will be slow since very little is known at present about the molecular factors that control the properties of such materials. It is suspected, for example, that the extent of molecular mixing at the polymer-polymer interface plays a major role in controlling the tensile strength of a heterogeneous polymer. However, until more is known about the polymer-polymer interface, the importance of it remains a supposition, and progress toward the goal of improved polymer properties will be limited.

Studies are underway at MMI to explore heterogeneous polymers. A theoretical effort will be directed toward an understanding of the molecular factors that control polymer incompatibility, the nature of the polymer-polymer interface, etc. This work will, in turn, provide guidance for an experimental program to be initiated to relate molecular properties to the physical properties of heterogeneous polymers.