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Polymer Science in Hungary, Part III. The Industrial Research Institutes and their Factories

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Centers of Polymer Research

Polymer Science in Hungary

Part III. The Industrial Research Institutes and their Factories

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IN MEMORY OF GYULA HARDY

Plastic materials have been produced industrially in Hungary for over a hundred years. Plastics processing was already carried out in Hungary in the 1920's. Although polymeric materials were produced and used before World War II it was not until after the war that the production and use of polymers increased rapidly. At the present time, PVC, polyethylene and polypropylene, (Trademarks: Ongrovil; Tipolen and Tipelin; and Tipplen) are produced and processed in large quantities.

In order to assist the development of the Hungarian plastic industry, it was thought necessary to establish industrial research institutes which could be responsible for the developments needed for industry and to find solutions for industrial problems. The Research Institute for Plastics, and also the Research Institute for the Or-

ganic Chemical Industry have been established for this purpose. Macromolecular research is carried out in both these industrial research institutes.

I. INDUSTRIAL RESEARCH INSTITUTES

1. The Research Institute for Plastics, Budapest

The Research Institute for Plastics (MUKI) was founded in 1950; its objective was to establish a scientific R/D background to accelerate the development of the plastic industry in Hungary.

MUKI has 350 employees, 90 of which are research associates. The main activities of the institute have been (since its foundation): To develop and update the tech-

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nologies of chemical syntheses; to develop the technologies for processing traditional and novel plastic materials, and also to promote the efficient utilization of plastics materials.

The budget of the Institute was originally provided by the state; since 1968 it has had to function independently, and must maintain its activities from outside support. As a consequence, the activities now stress quickly realizable results; for example, the contribution of MUKI to the adaptation and improvement of foreign licenses bought by Hungarian companies has been considerably increased. As a result of the greater openness of the Hungarian economy, the Institute purposely is trying to achieve a constructive role between foreign and Hungarian firms in introducing modern technologies. In addition, MUKI is placing greater emphasis on the possibility of marketing their scientific achievements to foreign countries.

Professor Gyula Hardy, had been the director of the Institute for more than 30 years. In April 1988, Dr. Sandor Doubravszky, who had been working on cationic and anionic polymerization of caprolactam, and had been scientific deputy director of MUKI, was appointed director.

The following departments are part of MUKI:

- Department of Macromolecular Chemistry and Technology (Dr. Tibor Czvikovszky, Head, Dr. Gabor Kovacs, Dr. Peter Hirschberg);
- Department of Polymer Physics (Professor Geza Bodor);
- Department for Polymer Processing (Peter Seida, deputy director, Dr. Miklos Deri, Head, Agnes Perenyi, Istvan Poka);
- Department for Application of Plastics (Dr. Sylvia Orban, Head, Dr. Lazlo Fuzes, Dr. Istvan Haklits);
- Chemical Pilot Plant (Gyorgy Cselik, deputy director, Gabor Vidra, Dr. Istvan Antal);
- Department of Mechanical Engineering Technology (Geza Kecskemethy).

Although the main activity of MUKI is applied research and development, scientists of MUKI have achieved international recognition also in basic research.

Professor Gyula Hardy's research group (headed by Dr. Karoly Nyitrai, and Dr. Ferenc Cser, are internationally recognized in the field of Polymerization in the Solid and Liquid Crystalline Phase. They were among the first in the 60's to recognize and establish the importance of the essential features of solid phase polymerization. They clearly stated, that for the formation of liquid crystalline polymers, an ordered state of the monomer is *not* required and they worked out methods for characterization of structures of liquid crystalline polymers. The general conditions of mesomorphism, as well as special conditions of mesomorphic polymers have been characterized.

The Main Department of Macromolecular Chemistry and Technology in the field of Radiation Chemistry of Polymers is under the leadership of Janos Dobo. The technology of thermally shrinking polyethylene was worked out on the basis of their theoretical investigations—it was developed in cooperation with industry.

Research on the Technology of Electron-Beam (EB) Curing of thin polymer layers is led by Tibor Czvikovszky. The laboratory is equipped with two pilot-scale electron accelerators, a Co-60 gamma source, pilot-scale plastics-processing which is combined with coating equipment; it has developed EB- and UV-reactive systems, and improved crosslinking of multi-component systems and radiation-cured composites. On this basis, the production of cement-bonded chipboards, EB-coated with speciality acrylates, fitted with two EB-accelerators of 250 kV each is now in production in Hungary.

The department headed by Peter Hirschberg has been studying the synthesis of oligomers and their application potential. The group is mainly interested in the development of saturated and unsaturated polyesters, vinyl esters and their composites. Of special importance is the study of the kinetics of polycondensation reaction and the behavior of ion-containing polymers (Dr. Ibolya Vancso).

The department working under Gabor Kovacs's leadership has been carrying out extensive research work on Acrylate and Urethane Chemistry; they are also involved in the study of biological and biomedical use of polymers, especially Microcapsulated Pesticides, Transdermal Me-



Research Institute for Plastics (MUKI).



Department of Plastic's Processing of MUKI.

dicaments for humans. They are also investigating Interpenetrating Network Structures and improvements in the production of polymer membranes for filtration processes.

The research group on Micromorphology of Polymers, and Applied Polymer Physics is led by Professor Geza Bodor. Electronmicroscopy, X-ray Analysis, Infrared Spectroscopy, and Gel Permeation Chromatography are used for most of their studies. Characteristics of the phase structures of polymer systems, such as the long period-values, the inertia radius, the correlation function of electron-density and the crystalline particle distribution have been investigated. Special methods have been developed for the determination of crystalline particle size distribution of semi-crystalline polymers on the basis of the wide-angle line profile widening. For the determination of specific amorphous orientation this was done in combination with an ultrasonic wave technique and with wide and small-angle X-ray diffraction techniques.

Applied polymer physics research is concerned with the thermal, mechanical and electrical investigation of the polymers.

Relaxation Properties of Polymers have been investigated for a long time at MUKI, by the group of Dr. Peter Hedvig. A very useful instrument, "Multi-relax", has been developed, which makes it possible to measure stress-relaxation, creep and shrinking characteristics of polymers.

The Main Department of Polymer Processing is involved in the determination of optimal processing parameters, and the relationship between the technological parameters and the properties of the end products. One of the objectives of this work is to extend the applicability of the thermoplastics polymers made in Hungary (PVC, LDPE, LLDPE, PP, PA) to their maximum uses by systematic modification of these polymers (e.g. blending with other polymers, fillers, reinforcing materials and special additives).

Research on Technically and Economically Efficient Utilization of Polymers is concentrated in the Main Department for Application of Plastics. The activities of the Main Department are involved with problems of degradation, weathering, stabilization and combustion of polymers and with problems of the use of polymers for packaging applications, and the application of polymers in the construction-industry, electrical- and electronic-industry and in agriculture. A Technical Information Center was organized in the Main Department which provides essential information for industry, with catalogs and computer data system. Its purpose is to pin-point the technically and economically optimization of polymer systems for the desired applications.

In the Chemical Pilot Plant, the Scale-up of the Laboratory Processes which had been worked out in the departments of the institute is being pursued; a pilot plant is responsible for the development of complete manufacturing processes. In the last few years, research has been focused on aqueous dispersion of vinyl acetate and acrylate types of polymers and copolymers. Reactive diluents have been applied to epoxy systems and to special polymer-based additives, both on a laboratory and on a pilot plant scale. A new technology was worked out for

the production of epoxy resin with low molecular weight. Several thousand tons of epoxy resin have been produced in Hungary based on the process patented by MUKI.

The Department of Mechanical Engineering Technology is dealing mainly with the development of technologies of mechanical engineering for the production of composites of unsaturated polyesters and other polymers to provide modern composite products. The machines developed in the department and partly manufactured in the department are now used in several Hungarian and even some foreign factories for producing polyester corrugated sheets, preregs and polyurethane foams, as well as for molding and injecting polyester resin. Color indicators have been developed for the detection of organic peroxy-catalysts, which proved to be very effective in polyester production. A filter for a foundry has been developed on a polymer base, that can be applied to very high temperatures.

2. Research Institute for Organic Chemical Industry Budapest, [SZEVIKI]

The Institute performs research/developing activities for the organic chemical industry, for the pharmaceutical-, pesticide producing and plastic industry. Director of the institute is Dr. Attila Kistamas, the scientific deputy director is Dr. Gyula Kortvelyessy.

Research work on additives and processing aids for polymers, which was originated and directed by Dr. Gyorgy Ocskay, the previous director of the institute, is about 20% of the SZEVIKI's activity.

Degradation and Stabilization Processes of PVC have been studied at SZEVIKI for about ten years, initially under Dr. Gyorgy Ocskay's and then under Dr. Gyla Levia's direction. The investigations are focussed on kinetic studies which are based on the evaluation of infrared spectroscopic data of PVC sheets stabilized with metal stearates. Kinetic equations have been derived for dependence of the concentration of metal stearate and ester groups as a function of time; the rate of formation of stearic acid has also been investigated. Substitution of allylic chlorine atoms of the polymers by stearate groups of the stabilizers (Fry and Horst's mechanism) was found to be an ionic reaction; the substitution rate depends on the concentration of ions, in accordance with the Debye-Huckel theory. The ions are originated mainly by the dissociation of metal stearates, but it is influenced and retarded by complex formation of the two kinds of metal stearates. Decrease of the concentration of ions increases the rate of the substitution of allylic chlorine, which causes the stabilizing effect. Further complex-formation, by adding pentaerythritol and ionic (antistatics) additives seems to prove the validity of this working hypothesis.

The Laboratory of Application Technique of the SZEVIKI also provides a Documentation and Information Service with a computerized data bank (Ms. Zsuzsa Anger-Szilagyi). The newest research results from Hungarian and international scientific investigations are published regularly in the journal STABINFORM which is edited by scientists of SZEVIKI.

For the industrial exploitation of the scientific results of SZEVIKI and in attempts to provide markets for new

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Hungarian products, the Institute also conducts marketing activities.

The Department of Intermediates also has a group involved in the investigation of Synthesis of Polymer Additives, which is under the leadership of Tibor Wein, Dr. Tama Szabolcsi and Kornel Szijarto. In the Laboratory of Application Technique, led by Dr. Zsuzsa Nyitrai, the Effect of Additives is being studied. As a result of these activities the synthesis of several thermal stabilizers, quenchers and light stabilizers for PVC (trade-name ONGROSTAB), as well as novel blowing agents (EVIPR) has been developed. Polymer compositions involving these new additives are already in industrial production.

An important part of the activities of the SZEVIKI is the study of the Effect of Polymer Products on the Human Organism, e. g. the selection of the appropriate materials for food packaging. Members of the Institute took part in the compilation of the so-called "Positive List" of the plastic industry (a list of polymers and additives permitted to be used for food packaging).

The Institute has been cooperating also with different foreign firms for the development of polymer additives.

II. DEVELOPMENT OF INDUSTRIAL ENTERPRISES

The consumption of plastic materials increased in Hungary at a rapid pace in the period following World War II. The import of polymers burdened the balance of the foreign trade of the country with increasing seriousness. Therefore the development of the polymer producing industry became inevitable. The problem was, that the capacity of polymer producing plants that work with maximum efficiency, exceeded the needs of the internal market of the country with a population of ten million. To surmount these difficulties there was one reasonable way: to produce only a few types of polymers in economically functioning high capacity plants, to export the excess, and to import the plastics materials not produced in

Hungary.

At present Hungary exports suspension PVC (trade-mark Ongrovil), polypropylene (Tipplen), and linear polyethylene (Tipelin) in substantial amounts. Ion exchange resins (Varion) epoxy and polyester resins and cellulose nitrate for the paint and varnish industry are also exported, but in smaller amounts.

The Plastics production in Hungary in 1987 was in excess of 500,000 tons. The Plastics consumption in Hungary is presently about 50 kg/person, somewhat less than in some of the industrialized countries in Europe, e.g. United Kingdom, Italy, France. While industrial production of plastics material in Hungary has increased slowly, the processing and utilization of polymers is developing much more rapidly. A summary of the individual companies and their product lines is shown in Table 1.

Some factories of the plastic industry have also organized their own research groups and laboratories for the rapid solution of their day-to-day problems to support their production and for some modification in the processes. Several of the new products developed in these laboratories have been commercialized. The research groups of some of the larger companies maintain good relations with the Research Institutes mentioned in this article, and in Part I and II of this series; they are also in close contact with other institutes and with universities.

The data describing the most important factories of the plastic industry in Hungary, as well as their products and their activities of cooperation are listed in Table 1.



View on "Tisza Chemical Works."



View of the Parliament from the Castle Hill.

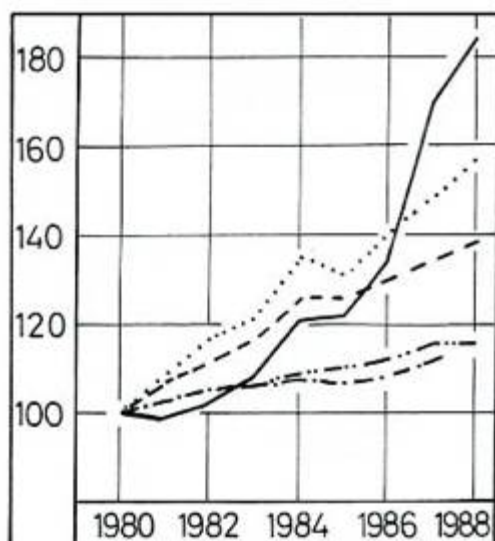
Table 1. Some Information about the Most Important Hungarian Plastics Companies

Name and Company Location	Abbr.	Production	Development	Institutional Cooperation*
Chemical Complex of Borsod (Borsodi Vegyi Kombinat), Kazincbarcika	BVK	Production of PVC powders and granules chlorinated PVC polyamide block polymer and granules, MDI and PUR, processing aids. Processing of PVC (for construction-industry, furniture, cars, packaging), polyolefins, polystyrene, polyurethane and engineering plastics.	New PVC and PVC-based blend types. PUR (prepolymers and mixtures). Polymer-based paints and adhesives. Processing aids.	MUKI, KKKI, SZEVIKI
Paint and Synthetic Resin Works (BUDALAKK Fetekes Mogyantagyar), Budapest	BUDALAKK	Products for the paint and varnish industry, Bonding materials based on polyester-amine resins and acrylate-copolymers.	New types of varnishes and adhesives based on alkyl-, amino- and vinyl-copolymer resins. Water diluted and dispersive bonding materials. New environment protective solvent-free and aqueous paints.	JATE, VVE, KKKI, BME
North-Hungarian Chemical Works (Eszakmagyarorszag Vegymuvek), Sajobabony	EMV	Polyurethane hard and soft foams for furniture, construction and textile-industry intermediates.	PUR and formaldehyde-based plastics. Improved flammability.	MUKI, ETI SZIKKTI, AUTOKUT, INNOVATEXT, BFV
Graboplast, Cotton-weaving Mill and Artificial Leather Factory (Graboplast, Gyori Pamutzovo es Muborgyar), Gyor	GRABOPLAST	PVC- and PUR- based artificial leather products, PVC floor coverings, vinyl-based wall-papers. PP staple fibers. Synthetic silk cloth, non woven textiles, adhesive tapes, PVC-based sealing compounds for food packaging, tilt for trucks, store tents.	Development of processing technologies. New PVC products for water isolation. New adhesives and plastisols. Antistatic floor coverings. Products for the automotive industry. Non woven textiles.	MUKI, SZEVIKI, INNOVATEXT, BME, MAFKI, KKKI, BCK
Hungarian Viscose Factory (Magyar Viscosagyar), Nyergesujfalu	MV	Fibers: viscose (Macosa), polyamide (Danamid), polyacrylonitrile (Crumeron), polypropylene (Propil). Polyamide granules. Polymer nets and grates (Netlon). Dref carpet yarn. Intermediates, CMC products (Mavibond).	New types of poly(acrylonitrile) and Viscose fibers. Processing of engineering thermoplastics. Biotechnology. Ultra-filter membranes.	MUKI NEVIKI BME
Nitrokemia Industrial Works (Nitrokemiai Ipartelepek), Fuzfogyartelep	NIKE	Production and processing of polyester resins. Ion-exchange resins. Polystyrene processing. Intermediates.	Development of ion-exchange resins. Styrofoam polystyrene. Polyester composites.	KKKI, MAFKI, BME, ELTE, JATE, VVE

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Table 1. Some Information about the Most Important Hungarian Plastics Companies (cont'd)

Name and Company Location	Abbr.	Production	Development	Institutional Cooperation*
PANNONPLAST Works (PANNONPLAST Muanyagipari Vállalat), Budapest	PAN-NON-PLAST	PVC floor coverings (Colorvinil, Colorvinilelastic, Hungelast, Hungiflex, Hungibod, Hungelit). PVC pipe and fittings. Different types of film (for water isolation, furniture, food packaging, agriculture, etc.). Injection molded products. Food packaging cups and boxes. Air/air heat-exchanger. Plastic ground covers for playing fields.	Products for construction-industry. Packaging materials. Processing of engineering thermoplastics. Reprocessing.	MUKI, KKKI, BME, GAMF
Pest County Plastic Processing Company (Pest Megyei Muanyagipari Vállalat), Solymar	PEMU	Polyolefin pipes (up to 630 mm diameter) and fittings. Thermoplastic sheets. PP and PTFE pumps for chemicals. Processing of PTFE and silicone rubbers. PUR products. Blow molding, injection molding. Thermoplastic compounds. Compounds with improved flammability. Sporting shoes, parts for footwear.	Plastic parts for automobiles. Garden furniture. Injection molded engineering plastics. Compounds, blends and composites.	MUKI, KKKI, SZEVIKI, BCK
TAURUS Hungarian Rubber Works (TAURUS Gumipari Vállalat), Budapest	TAU-RUS	Wide scale of rubber products. Machines for rubber processing.	Vulcanization of ethylene/propylene ter-polymers with resins. Special rubber products with high dielectric strength. Electrostatic rubbers. PUR products with steel cord layer.	KKKI, MUKI
Tisza Chemical Works (Tisza Vegyi Kombinat), Leninvaros	TVK	Production of olefins, polyolefins (PE, PP) paints and fertilizers. Polymer processing.	Increasing olefin production. Special types of polyolefins. Special polymer blends and compounds. Adaptation of new technologies in polymer processing.	MUKI, SZEVIKI, KKI, BME, VVE
Electrical Insulating Materials and Plastic Factory (Villamoszigetelo es Muanyaggyar), Budapest	VSZM	Injection molding and extrusion of thermoplastics. Compression molding of aminoplasts and phenoplasts. Processing of glass fiber reinforced polyester resins. Heat shrinkable goods from irradiated PE. Friction products. Laminates.	Physical and chemical cross-linking of polyethylene. Reinforced friction products free of asbestos. PS/PMMA blends. Application of different additives	MAFKI, EMI, MEEI, MUKI, KKKI, ELTE, GAMF



..... national income
 - - - - - industrial production
 - - - - - consumption of plastics
 - processing of plastics
 _____ production of plastics



Museum of Fine Arts, Budapest.

***Definitions of Institutes**

AUTOKUT	Research and Development Company for the Automotive Industry
BCK	Research Institute of the Leather and Footwear Industry
BFV	Development Institute for Furniture Industry
BME	Technical University of Budapest.
ELTE	Eotvos Lorand University of Science, Budapest
ETI	Hungarian Institute for Building Science
GAMF	College of Mechanical Engineering and Automation
INNOVATEXT	Innovatext Textile Engineering Company
JATE	Jozsef Attila University of Sciences, Szeged
KKKI	Central Research Institute of Chemistry of the Hungarian Academy of Sciences
KLTE	Kossuth Lajos University of Science, Debrecen
MAFKI	Hungarian Oil and Gas Research Institute
MEEI	Hungarian Institute for Testing Electrical Equipment
MUKI	Research Institute for Plastics
NEVIKI	Research Institute for Heavy Chemical Industries
SZEVIKI	Research Institute for the Organic Chemical Industry
SZIKKTI	Central Research and Design Institute for Silicate Industry
VVE	Veszprem University of Chemical Engineering, Veszprem

The main direction in the industrial development of plastics materials in Hungary is the development of specialty plastics by means of establishing new production branches (PUR, PETF), and through modification of large scale polymers.

The plastic industry, which has been one of the fastest developing branches of the Hungarian industry in the last 20 years requires also an intensive research activity. Some of the conditions of the World Bank's credit are the reorganization, intensification and increased independence of the research centers of the factories. The further development of polymer research and that of the plastic industry is expected to be promoted by the growing number of joint enterprises, which are partly owned by companies of industrialized countries (Federal Republic of Germany, Italy, U. S. A., Japan) but are based on the social changes presently taking place in Hungary.