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

Otto Vogl, University of Massachusetts - Amherst
Gyula Hardy
Sandor Doubravsky
Margit Iring
Ferenc Tudos

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Center of Polymer Research

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Part III. The Industrial Research Institutes and their Factories

Gyula Hardy (a), Sandor Doubravszky (a), Margit Iriing (b), Ferenc Tudos (b,c) and Otto Vogl (d)
(a) Research Institute for Plastics, Budapest
(b) Central Research Institute for Chemistry of the HAS, Budapest
(c) Eotvos Lorand University of Sciences, Budapest
(d) Polytechnic University, Brooklyn, NY 11201 USA

IN MEMORY OF GYULA HARDY

Plastic materials have been produced industrially in Hungary for over a hundred years. Plastic 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; Tipolex and Tipol; and Tipple; and Tipple) 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 Organic 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 1956; 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 researchers associated. The main activities of the institute have been (since its foundation): To develop and update the tech-
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 licencases 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 20 years. In April 1988, Dr. Sándor Debrecenzky, 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 Géza Bodor);
- Department for Polymer Processing (Peter Seida, deputy director, Dr. Miklós Deri, Head, Agnes Perenyi, Istvan Pokai);
- 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 Antall);
- Department of Mechanical Engineering Technology (Géza Keckemethy).

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 Nyítrai, and Dr. Perenc Csér, 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 nesomorphism, 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. Iboya Vanco).

The department working under Gabor Kovacs's leadership has been carrying out extensive research work on Acrylate and Urethanes Chemistry; they are also involved in the study of biological and biomedical use of polymers, especially Microcapsulated Pesticides, Transdermal Me-
dicaments for humans. They are also investigating inter-
penetrating Network Structures and improvements in
the production of polymer membranes for filtration
purposes.

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 inertial radius, the correlation function
of electron-density and the crystalline particle distribu-
tion 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 determi-
nation of specific amorphous orientation this was done in
combination with a uniaxial 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 investi-
gated 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 in-
volved in the determination of optimal processing para-
eters, and the relationship between the technological
parameters and the properties of the end products. One of
its objectives is to extend the product line of the
thermoplastics polymers made in Hungary (PVC, LDPE,
LLDPE, PP, PA) to their maximum use by system-
atic 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 degrada-
tion, weathering, stabilization and combustion of poly-
mers and with problems of the use of polymers for pack-
aging 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 essen-
tial information for industry, with catalogues 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 Labo-
atory Processes which had been worked out in the de-
partments of the institute is being pursued: a pilot plant
is responsible for the development of complete manufactur-
ing processes. In the last few years, research has been
focused on aqueous dispersion of vinyl acetate and
acylate types of polymers and copolymers. Reactive dilu-
ents 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 Technol-
ogy is dealing mainly with the development of technolo-
gies of mechanical engineering for the production of com-
posites of unsaturated polyesters and other polymers to
provide modern composite products. The processes de-
veloped 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, prepregs and polymeric wall panels, and for
molding and injecting polyester resin. Color indicators
have been developed for the detection of organic perox-
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 tempera-
tures.

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

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

Research work on additives and processing aids for
polymers, which was original and directed by Dr.
Gyorgy Ocakay, 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. Ten years, initially
under Dr. Gyorgy Ocakay's and then under Gyula
Levai's direction. The investigations are focused on ki-
netic studies which are based on the evaluation of infra-
red spectroscopic data of PVC 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 Horov's mechanism) was found
by an ion reaction; the substitution rate depends on
the complexion of ions, in accordance with the Dbsby-
Huckel theory. The ions are originated mainly by the dis-
sociation of metal stearates, but it is influenced and re-
tarded 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 pentaerithritol 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
enger-Szilagyi). The newest research results from Hun-
garian and international scientific investigations are pub-
lished 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
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. Tamas 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) have 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, exceed 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 Ongroval), polypropylene (Tipion), 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.
<table>
<thead>
<tr>
<th>Name and Company Location</th>
<th>Abbr.</th>
<th>Production</th>
<th>Development</th>
<th>Institutional Cooperation*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chemical Complex of Borsod (Borsodi Végyl Kombinat), Kazincbarcika</td>
<td>BVK</td>
<td>Production or 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.</td>
<td>New PVC and PVC-based blend types. PUR (prepolymers and mixtures). Polymer-based paints and adhesives. Processing aids.</td>
<td>MUKI, KKKI, SZEVIKI</td>
</tr>
<tr>
<td>Paint and Synthetic Resin Works (BUDALAKK Fetekes Mogyantagyar), Budapest</td>
<td>BUDA-LAKK</td>
<td>Products for the paint and varnish industry, Bonding materials based on polyester-amine resins and acrylate-copolymers.</td>
<td>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.</td>
<td>JATE, VVE, KKKI, BME</td>
</tr>
<tr>
<td>North-Hungarian Chemical Works (Eszakmagyarorszagi Vegymuvek), Sejobabony</td>
<td>EMV</td>
<td>Polyurethane hard and soft foams for furniture, construction-and textile-industry intermediates.</td>
<td>PUR- and formaldehyde-based plastics. Improved flammability.</td>
<td>MUKI, ETI, SZEKI, AUTOKUT, INNOVATEX, BFV</td>
</tr>
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<tr>
<td>Taurus Hungarian Rubber Works (TAURUS Gumipari Vállalat), Budapest</td>
<td>TAURUS</td>
<td>Wide scale of rubber products. Machines for rubber processing.</td>
<td>Vulcanization of ethylene/propylene ter-polymers with resins. Special rubber products with high dielectric strength. Electrostatic rubbers. PUR products with steel cord layer.</td>
<td>KKKI, MUKI</td>
</tr>
<tr>
<td>Tiszta Chemical Works (Tiszai Vegyi Kombinat), Leninvaros</td>
<td>TVK</td>
<td>Production of olefins, polyolefins (PE, PP) paints and fertilizers. Polymer processing.</td>
<td>Increasing olefin production. Special types of polyolefins. Special polymer blends and compounds. Adaptation of new technologie in polymer processing.</td>
<td>MUKI, SZEVIKI, KKI, BME, VVE</td>
</tr>
</tbody>
</table>
**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
- **INNOVATEX T** Innovatext Textile Engineering Company
- **JATE** Joszef Attila University of Sciences, Szeged
- **KKKI** Central Research Institute or 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
- **SZIKKI** 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, PETP), 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.