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Michael Szwarc. An Appreciation

Michael Szwarc received his early education in Warsaw, Poland, and his first doctorate from Hebrew University, Jerusalem, but it was while at the University of Manchester that the thoroughness and precision of his analytical abilities became apparent internationally. There he developed a method of determining bond dissociation energies by pyrolysis, isolating the products of unimolecular homolytic scission reactions by the use of toluene as a carrier gas and determining the activation energy of the process. In the pyrolysis of *p*-xylene and related compounds, the corresponding quinone dimethides were formed as species, stable in the gas phase, that polymerized when condensed, to form the *p*-xylylene family of polymers, Michael's first contribution to polymer science.

It was surprising to a small group of polymer and wood chemists, recently organized into a Department of Chemistry at the New York State College of Forestry, to learn, in 1952, that this distinguished scientist was to join our faculty. We were painfully aware of our limited resources and obsolete laboratories. However, Baker Laboratory was on the drawing boards and our administrators, Hardy Shirley and Edwin Jahn, were more confident and were able to project their confidence and support to Michael.

Michael proved to be a veritable dynamo. The old laboratories underwent magical transformations. Syracuse University, with which we were loosely affilitated, and especially its Chemistry Department and kindly chairman, Henry Wirth, assisted in many ways. But perhaps the greatest change was in the energy and enthusiasm that was absorbed by the younger members of the faculty.

Vivian Stannett, a faculty member at that time, had developed a close association with the personnel of the Technical Association of the Pulp and Paper Industry (TAPPI) and was aware of their interest in finding a more fundamental approach to packaging problems. He and Michael obtained substantial grants from TAPPI and the U.S. Army Quatermaster Corps to study the permeability of plastic films and coated papers to gases and vapors. The grants supported a continuing productive collaboration that lasted for several years. Their approaches and the data they collected are basic to membrane science and technology, a field not then considered important, but one in which graduates of their program are still making substantial contributions.

For my part, in addition to lignin studies, I had become interested in demonstrating asymmetric induction in a polymerization process and had discussed the problem with Charles Overberger. With customary generosity, he shared with me his experience and also told me of the work of Speed Marvel on optical activity in polymers. I was thus encouraged to mention to Michael my synthetic plans. Michael was intrigued and closeted himself with Harry Frisch, then a postdoctoral fellow in physics at Syracuse University. Together they developed a general treatment of asymmetric polymerization. I added the obvious structural requirements. The paper, which appeared in 1953, was later described by Professor Mario Farina as the "starting point for all future developments". (Farina, M. In *Guilio Natta, Present Significance of his Scientific Contribution*; Editrice di Chimica srl, 1982.) For me this was the beginning of a career-long engagement with stereochemical control in polymerization processes. For Michael it was a mere incident.

Michael's main effort at this time was to direct his research away from the study of bond dissociation energies to an area more immediately related to polymer chemistry. He first chose to use similar techniques to investigate radical reactivities in addition, abstraction, recombination, and disproportionation reactions. His work on methyl, ethyl, trifluoromethyl, and other alkyl "affinities" rapidly provided a body of quantitative data related to monomer reactivity, initiation efficiency, and inhibition and chain-transfer processes. The research included an investigation of the influence of radical source, cage effects, condensed and gas phase reactions, and structural features: ster-

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eoisomerism, conjugation, polar influences, and steric hindrance.

A visit to Sam Weissman's laboratory gave Michael an insight that was to lead him to his most important contribution to polymer chemistry. Weissman was investigating electron transfer between aromatics using solutions of alkali metals in ethereal solvents. The changes were followed by electron spin resonance. However, styrene did not behave "normally". It gave a beautiful red color, but no ESR signal, and a gum was produced. Michael immediately recognized that dimerization must have occurred with the formation of a dianion that polymerized. With Weissman's permission to explore the polymerization, Michael immediately began his research on "living polymers" and was able to define conditions for the preparation of polymers of controlled structure including monodisperse, multichain, and defined block and graft copolymers. This work produced a worldwide resurgence of interest in anionic polymerization in both industry and academia and stimulated attempts at greater control of cationic polymerizations.

Typically, Michael was not satisfied until all aspects and implications were explored, the kinetics and thermodynamics of propagation, the structure and solvation of ion pairs in low dielectric media, electron-transfer processes, radical ions and so on. The variety of experimental techniques that he brought to bear on these problems was remarkable and was an impressive education for the 45 doctoral students he supervised and the ~50 visiting scientists and postdoctoral fellows his work attracted. The lasting significance of his work is indicated by the fact that there have been over 100 references to his publications each year since his nominal retirement.

Michael has an intensely enthusiastic and explosive personality. Many a time, lacking a more suitable audience, he would seize me and try to make my qualitative mind appreciate the beauties of his latest quantitative correlation. Some explosions caused irritation, but it is easy to remember many exceptional personal and professional generosities. In addition, beyond working hours, he and his gracious wife Marysia often invited friends and out of town visitors to their home for stimulating conversation and gourmet fare. Their artistic interests and tastes were apparent in their home and occasionally Michael would favor us with a short recital at the piano, but only on urging.

Michael is an excellent swimmer and a view of a tiny head far out in the water was a common feature of an afternoon at the lake when Michael attended the Gordon Conferences on Polymers or those on Radical Ions, which he initiated. He is also an active gardener, and after a quarter century's testing time in Syracuse, he can now presumably indulge this interest with still more rewarding results in California. Michael's family is also a very important part of his life and he often expresses the pleasure and satisfaction they give him.

Those of us who have shared the stimulation and excitement of working near Michael send him our greetings on this 80th birthday, best wishes for the future, and congratulations on his lasting place in the scientific endeavor.

Selected Publications

1. Szwarc, M. The Determination of Bond Dissociation Energies by Pyrolytic Methods. *Chem. Rev.* **1950**, *47*, 75.
2. Szwarc, M. The Monomers of the Type CH_2:C_6H_4:CH_2 and Their Polymers. *J. Polym. Sci.* **1951**, *6*, 319.
3. Szwarc, M. Reactions of Methyl Radicals and their Application to Polymer Chemistry. *J. Polym. Sci.* **1955**, *16*, 367.
4. Szwarc, M.; Levy, M.; Milkovich, R. Polymerization Initiated by Electron Transfer to Monomer. A New Method of Preparation of Block Polymers. *J. Am. Chem. Soc.* **1956**, *78*, 2656.
5. Szwarc, M. *Carbanions, Living Polymers, and Electron-Transfer Processes*; Interscience Publishers: New York, 1968.
6. *Ions and Ion Pairs in Organic Reactions*; Szwarc, M., Ed. John Wiley and Sons, Inc.: New York, 1974.

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