

Preface

Life and modern society cannot be imagined in the absence of natural and synthetic macromolecules. This volume of *Advances in Polymer Science* is dedicated to the 60th anniversary of the Nobel Prize received in 1953 by Professor Hermann Staudinger (23 March 1881–8 September 1965) “for his discoveries in the field of macromolecular chemistry.”

Natural and synthetic macromolecules were known long before Staudinger. However, the status of macromolecular compounds is best reflected by the friendly advice received by Staudinger from Heinrich Otto Wieland, Nobel Prize laureate in 1927. “Dear colleague, abandon your idea of large molecules, organic molecules with molecular weights exceeding 5,000 do not exist. Purify your products such as rubber, they will crystallize and turn out to be low molecular weight compounds.” Staudinger also wrote in his memoirs: “Those colleagues who were aware of my early publications in the field of low molecular weight chemistry asked me why I decided to quit these beautiful fields of research and why I devoted myself to such disgusting and ill-defined compounds such as rubber and synthetic polymers which at that time in view of their properties were referred to as grease chemistry (‘Schmierchemie’).” The contributions of Hermann Staudinger to the field of macromolecular chemistry, for which he was awarded the Nobel Prize in 1953, are best illustrated by a discussion between the Emperor of Japan and Staudinger, that took place at the Imperial Palace of Japan on 17th of April 1957. His Majesty Emperor Hirohito of Japan asked, “Professor Staudinger, is this a concept that came into your mind to explain various phenomenological behaviors of a group of compounds or did you really prove their existence by rigorous scientific means?” The highly impressed Professor Staudinger answered, “It is this experimental demonstration of the existence of macromolecules which form the essential part of my work in the field of macromolecular science.” Therefore, it was Staudinger who demonstrated the covalent rather than colloidal structure of macromolecules.

During the early days of the twentieth century, organic chemists were convinced that natural and synthetic macromolecules were colloidal aggregates of low molecular weight compounds. Staudinger obtained his Ph.D. at the age of 22, with Daniel Vorländer at the University of Halle in 1903. Subsequently, he held faculty

appointments at the University of Strasbourg (1903–1907) where in 1905 at the age of 24 he discovered ketenes. In 1907, he discovered the cycloaddition of ketenes with imines, still the most general and useful method for the synthesis of β -lactams. In the same year, he obtained his Habilitation in the laboratory of Johannes Thiele and moved to the University of Karlsruhe as a junior faculty where, in parallel with his work in the field of organic chemistry, he became interested in polymers. In 1912, at the age of 31, he moved to become full professor at ETH in Zürich and in the same year published his famous book on ketenes. In 1919, he discovered the reaction of azides with phosphines to produce phosphazenes and, subsequently, in the presence of water to yield primary amines. This reaction is known as the “Staudinger reaction” or “Staudinger reduction.” In the year 2000, the Staudinger reaction was expanded and elaborated by Carolyn R. Bertozzi into the “Staudinger ligation,” which has been labeled by some authors as “a gift to chemical biology.” The three Staudinger reactions mentioned here are fundamental in organic chemistry and numerous publications discussing and debating their mechanisms, as well as reviews on them, are being published as I am writing this Preface. No references to them are listed here because most of them are cited in the publications of this special issue. A search of SciFinder will help those interested in finding recent publications on his work and on the very active current research on the Staudinger reactions.

In a publication from 1920, Staudinger coined the name “Makromoleküle” and in 1922 he generated the correct definition of “macromolecules,” stating: “For such colloid particles, in which the molecule is identical with the primary particle, and in which the individual atoms of this colloid molecule are linked together by covalent bonds, we propose for better definition the name macromolecule.”

In 1926, he moved to the University of Freiburg to replace his “friendly adviser” Heinrich Otto Wieland, who was to be awarded the Nobel Prize in 1927. In Freiburg, Staudinger focused all his research on macromolecules and stayed until he retired from the University in 1951 and as Director of his Institute in 1956. Staudinger received the first Nobel Prize for the field of macromolecular chemistry in 1953, the same year that Watson and Crick published their *Nature* paper on the double helix of the natural macromolecule DNA. In 1940, Staudinger started the Institute of Macromolecular Chemistry at the University of Freiburg, the first in this field in Europe, which received the name “Hermann Staudinger Haus” in 1981. On 19 April 1999, the American Chemical Society together with the German Chemical Society honored the Staudinger Laboratory in Freiburg as an “International Historic Landmark of Chemistry.” Wallace H. Carothers, of the Experimental Station of Du Pont, and Hermann F. Mark, to name just two of many, were also influential in establishing the concept of polymers and macromolecules. However, it was the credibility and the reputation of Hermann Staudinger in the field of traditional organic chemistry who helped to set the future of “macromolecular chemistry” as the newest discipline of organic chemistry. If Hermann Staudinger had not started the field of macromolecular chemistry, he most probably would have received a

Nobel Prize for his work in organic chemistry earlier than he received it for macromolecular chemistry, just like his former student from Karlsruhe and Zürich, Leopold Ruzicka, who received it in 1939.



The photo shows on the left from back to front, Virgil Percec (a former postdoctoral student of Hans-Joachim Cantow in the Hermann Staudinger Haus), Helmut Ringsdorf (the last Ph.D. student of Staudinger), Hans-Joachim Cantow (a follower of Staudinger at the Hermann Staudinger Haus), and Hans-Rudolf Dicke (a former Ph.D. student of Walter Heitz). On the right are Martin Möller (a former Ph.D. and Habilitation student of Cantow) and Hubert Bader (a former Ph.D. student of Helmut Ringsdorf). The photo was taken during the IUPAC Symposium on Macromolecules in Amherst, MA, USA (12–16 July 1982). Four of these scientists have contributed to this special issue.

This special issue contains 38 scientific, personal and historic contributions from the fields of organic chemistry, supramolecular chemistry, macromolecular chemistry, bioorganic chemistry, computation science, biotechnology, and nanotechnology. This broad diversity of interests reflects Hermann Staudinger's diversity of scientific interests. From these many outstanding contributors I would like to mention Professor Urs T. Ruegg, one of Staudinger's grandchildren; Professor Helmut Ringsdorf, the last Ph.D. student of Hermann Staudinger; and Professor Jean-Marie Lehn (Nobel Prize in 1987), the inventor of the fields of "supramolecular chemistry" and "supramolecular polymers," the most recent new disciplines of organic chemistry. Many of these contributions provide not only great science but also fascinating stories about the life of Hermann Staudinger, the scientist who paved the way for the birth of macromolecular chemistry and the development of most significant breakthrough technologies of the twentieth century.

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