Self-Assembly and Hierarchical Structure Formation of Macromolecules

It is now precisely 20 years ago that Helmut Ringsdorf wrote a famous review on self-organized polymer systems in which he developed a scenario of the future destination of macromolecular chemistry.[1] His key statement was: “In the meantime, macromolecular chemistry, too, has become a classical discipline, a mature science, with all the advantages and handicaps of maturity. Harvest is plentiful, the results are abundant – but one has to ask: where is the future, where are the adventures?” He also pointed to the fact that scientific adventure is always on the border with other disciplines, such as physics, biology, or pharmacy.

Well, even ‘mature’ polymer science can, does, and will evolve, and in our opinion nowadays develops with an even higher pace and more fruits than ever. There are a number of reasons for this, one of which being rather general: Because of the increasing number of polymer scientists in Asia and South America, improved communication and electronic publication systems, and an increasing professionalization of science in terms of management (the sum of these three aspects sometimes abbreviated as ‘globalization’), quality measures and the knowledge of the actual standing have been homogenized. This defines a common ‘coordinate system’ that allows young scientists more easily to start their career by working on the real problems at the forefront of research.

On the other hand, polymer science has indeed benefited from the exchange with other disciplines, such as inorganic chemistry, pharmacy, molecular biology, micro engineering, or modern metal organic chemistry. Fortunately, these new territories were not just explored, while leaving the old country behind, empty and devastated, but rather researchers brought the harvested fruit and gained knowledge back to render the ‘Good Old Lady of polymer science’ even more prosperous. Just a few examples are:

Microfluidics and lab-on-a chip technology heavily rely on optimized polymer materials, but in return also allow the generation of novel polymer micro- and nanostructures.

Modern metal–organic catalysts and coupling reactants enable the construction of new polymers with better control of tacticity, length, or electro/optical properties.

The transfer of concepts from zeolites and metal–organic frameworks back to polymer resins leads to micro- and mesoporous polymers, a new class of polymer that has the chance to revolutionize membrane and support chemistry.

Synthetic principles and machines developed in molecular biology, such as robotized synthesizers for sequence control, microwave chemistry and/or combinatorial synthesis/analysis have also been explored for the purposes of polymer science, giving methodological pushes for a higher development rate and a better primary structure control.

Finally the concepts of supramolecular science and dendrimers have been folded back to macromolecules, thus accessing the class of supramolecular and dendronized polymers with all their special benefits and properties.

It is the purpose of the present special issue to allow promising young polymer scientists to describe their concepts of the next generation of polymers in a compact, face-to-face presentation and to give their individual views on where polymer science is heading and what its potential benefits may be. It is no coincidence but a deliberate thematic choice that most of the publications deal with encoding self-organization into a primary polymer sequence or geometry which, if properly designed, results in pre-determined secondary and tertiary structures. This higher order structure control then allows distinct structural or functional problems to be solved.

It is not for granted that these concepts will indeed turn into the next blockbuster, but at least, this is where some younger colleagues presently sense the scientific adventures and opportunities of polymer science.

Markus Antonietti
Guest Editor
Max Planck Institute of Colloids and Interfaces, Golm, Germany

A. Dieter Schlüter
Guest Editor
ETH Zurich, Switzerland