# Editorial

# Molecular Electronics – From a Visionary Concept Towards Reality

Molecules are the smallest building blocks that still provide the structural diversity required for the definition of different electronic functions. Furthermore, generations of synthetic chemists have improved the skills of mankind to design and synthesize molecular structures with atomic precision.

Considering the constant feature size reduction in semiconductor electronics, which is predicted to soon hit both technological and economical limitations, the growing interest in exploring single molecules as the smallest potential building blocks is not surprising. But does size really matter? Is it really the smallness that makes molecules appealing building blocks for electronic applications? The only driving forces towards smaller feature sizes are the huge costs of wafer production and a small chip allows the production of more of them in parallel on the same wafer. Thus, the real driving forces are the costs and not the size of a chip. Considering the dimensional mismatch at the interface between the top-down fabricated electronic circuits with micrometer sizes and the bottom-up synthesized nanometer-scaled molecules, their tininess becomes rather a scientific challenge than a particular appealing feature of the functional unit. While the vision to tailor electronic properties by the molecular structure has already been proposed by Hans Kuhn with his conceptual work on *molecular engineering,*[1] it is mainly the increasing ability to observe and to control objects of nanoscale dimensions – triggered by more recent inventions like *e.g.* the scanning tunneling microscopy (STM) by Gerhard Binning and Heinrich Rohrer[2] – that drives the current revival of *molecular electronics*.

Besides the economic expectation for less expensive technical solutions, the main interest in *molecular electronics* is the appealing fundamental science that brings together researchers from various disciplines. Synthetic chemists are required to design and assemble the molecular building blocks while experimental physicists and physical chemists provide set-ups enabling the integration of molecules in electronic circuits. Transport models developed by theoreticians improve the comprehension of the correlation between molecular structure and electronic transport characteristics and their feedback provide the basis of the next generation of functional molecules.

This interdisciplinary character of *molecular electronics* is also reflected in this special issue of CHIMIA which comprises eleven short reviews, each summarizing achievements of a particular group in the field. Historically, molecular electronics was for quite a while mainly a topic in theoretical physics due to the limitation in available experimental approaches. Following this tradition, the first article from ***Magnus Paulsson***, ***Thomas Frederiksen*** and ***Mads Brandbyge*** is focused on the theoretical treatment of the contact between molecule and electrode. To study correlations between the structure of a molecular wire and its ability to transfer electrons, tailor-made model compounds for spectroscopic investigations are presented in the article from ***Peter Belser***. An economical setup to investigate electrical transport properties through self-assembled monolayers of various molecules is presented by ***Felice Simeone*** and ***Maria Anita Rampi*** with their mercury droplet junction. In order to study orbitals of individual decoupled molecules in STM experiments, the perturbations of the deposited molecules by the substrates are reduced with ultrathin insulating films in the studies presented by ***Jascha Repp*** and ***Gerhard Meyer***. Transport characteristics of single molecules in ultra high vacuum and at low temperature are discussed in the mechanically controlled break junction (MCBJ) experiments of ***Emanuel Lörtscher*** and ***Heike Riel***. Electrochemical control is added to single molecule junctions in the STM experiments presented by ***Chen Li***, ***Artem Mishchenko***, ***Ilya Pobelov*** and ***Thomas Wandlowski***. The formation of molecular junctions at room temperature where, for instance, intermolecular stacking plays an important role, is studied in a MCBJ and in large two dimensional gold nanoparticle arrays by ***Michel Calame***. Light switchable molecules are synthesized, integrated and investigated in the experiments discussed by ***Wesley Browne*** and ***Ben Feringa***. New integration concepts based on self-assembly mechanisms are presented in the article of ***Kasper Moth-Poulsen*** and ***Thomas Bjørnholm***. A new family of push-pull chromophores as promising materials

in opto-electronics is synthesized and discussed by ***Benjamin Breiten***, ***Ivan Biaggio*** and ***François Diederich***. Carbon nanotubes are particular appealing materials for electronic applications due to their unique physical properties. Approaches based on these objects are discussed by ***Jean-Philippe Bourgoin***, ***Stéphane Campidelli***, ***Pascale Chenevier***, ***Vincent Derycke***, ***Arianna Filoramo*** and ***Marcelo Goffman***.

This collection of articles is neither complete nor perfectly balanced. But it provides an overview of the current state of the art in molecular electronics. In spite of the fact that the developments and achievements of the last decade are impressive, there remains a huge amount of fundamental science to be explored and novel approaches will be required to pave the commercialisation of molecular devices in electronic applications.

[1] H. Kuhn, D. Möbius, *Angew. Chem. Int. Ed.* **1971**, *10*, 620.
[2] G. Binning, H. Rohrer, C. Gerber, E. Weibel, *Phys. Rev. Lett*. **1982**, *49*, 57.

Marcel Mayor

University of Basel, Department of Chemistry, St. Johannsring 19, CH-4056 Basel,
E-mail: marcel.mayor@unibas.ch
and
Karlsruhe Institute of Technology KIT, Institute of Nanotechnology, P. O. Box 3640,
D-76021 Karlsruhe, Germany, E-mail: marcel.mayor@kit.edu

***Marcel Mayor*** studied chemistry at the University of Bern where he worked together with Rolf Scheffold and Lorenz Walder for the period of his PhD in organic chemistry. During a post-doctoral stay with Jean-Marie Lehn in Strasbourg (France) he became familiar with the concepts of supramolecular chemistry. In 1998 he moved to Karlsruhe (Germany) to build up a synthetic chemistry group in the newly funded Institute of Nanotechnology of the Forschungszentrum Karlsruhe GmbH (today: Karlsruhe Institute of Technology KIT) focused on the assembly of tailor-made molecular nano-objects. Since 2005 he is professor of chemistry at the University of Basel. His current research interests are mainly chemical concepts in nanotechnology and range from molecular electronics over molecular interference experiments to functional materials.

It is with great pleasure that the Editorial Board of CHIMIA thanks the guest editor Prof. Dr. Marcel Mayor for the successful realisation of this special issue on Molecular Electronics; a lively interdisciplinary science with great potential for the future.