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Editorial: Building Block Approaches to Inorganic and Hybrid Materials

Guido Kickelbick and **Nicola Hüsing**

Chemistry in the last century has mainly focused on the exploration of phenomena in the making and breaking of bonds in small and large molecules and the electronic influences on these processes. The art of bond formation is now well-established for many compound classes. Thus, we have the tools in hand to form amazingly complex molecules, to mimic nature as the largest molecular manufacturer, and to explore molecules with a complexity our chemical ancestors did not even imagine. Inorganic chemistry followed these trends and developed various subclasses, such as solid state, transition metal coordination chemistry, and organometallic chemistry as well as main group chemistry. While the exploration of structure and bonding phenomena has been the main focus over many decades, in recent years, a novel trend can be observed: Chemists are no longer satisfied with the understanding of the reactivity of molecules and the formation of bonds or the generation of highly aesthetic molecules, but they are also focusing on functional aspects of molecules and the formation of materials from molecular compounds. This often requires novel approaches in the way of thinking which are based on interdisciplinary communication with scientists of different branches, such as biologist or physicists.

Materials chemistry adopted this new approach. Over many centuries, investigations in the production of materials have been based on trial and error approaches using minerals or biological materials as crude educts. It was probably the earning of the first findings in the new scientific branch of polymer chemistry that has totally changed the view in materials science during the last century. Scientists realized that materials can be developed deliberately in combining molecules to get novel substances with unique properties that have not been observed before. Materials chemists recognized that the deliberate design of materials properties requires the control of their molecular building blocks. It became clear that the toolbox of chemists, namely the knowledge of bond formation, developed over the centuries, is the prerequisite of the tailored formation of materials. Indeed many chemists with a strong preparative background can be found among the leading scientists in material science. It is only because we all have the tools in hands, which were developed by generations of chemists, that today we can construct materials with a high complexity and surprising functions. Truly . . . *"we are like*

dwarfs sitting on the shoulders of giants. We see more than they do, indeed even farther; but not because our sight is better than theirs or because we are taller than they. Our sight is enhanced because they raise us up and increase our stature by their enormous height." (Bernhard von Chartes)

Open minded chemists that are able and willing to look beyond the end of one's nose are necessary to explore these new fields in chemistry, and Prof. *Ulrich Schubert* definitely belongs to this class of chemists. In this special issue of Monatshefte für Chemie with the title "Building Block Approaches to Inorganic and Hybrid Materials" on the occasion of Prof. *Ulrich Schubert*'s 60^{th} birthday, many friends and former group members give an overview of developments in a molecular based materials chemistry. The broadness of the field is visible by the diversity of titles in this special issue that ranges from the synthesis and characterization of small molecules as precursor compounds to the preparation of highly complex functional materials. Inorganic–organic hybrid materials count to one of the most fascinating groups of new materials because they synergistically combine the properties of inorganic and organic components in one class of material. Their deliberate design is only possible because we are able to manage their molecular composition and structural build-up. The science of these materials ranges from the development of novel building blocks, over their processing, the characterization of the respective materials to their application. All of these areas are covered by this special issue and many of them were influenced by the work of Prof. *Ulrich Schubert* and his group. He belongs to the scientists who by their ideas and findings move this field forward. His strong preparative inorganic background and his analytical thinking resulted in deeper insights in this class of materials and created interest and fantasy in the preparation of novel materials all over the world.

We like to thank all contributors and referees for their time and effort in preparing this special issue. Special thanks to Prof. *Heinz Falk*, Managing Editor of Monatshefte für Chemie and Prof. *Peter Gärtner*, Editorial Assistant, for their support of this project.

From Molecules to Materials

. . . is not only a phrase that describes the evolution of inorganic–organic hybrid materials, but also *Ulrich Schubert*'s scientific career follows this path. He began his chemistry studies at the Technical University of Munich, where he was awarded a diploma degree in chemistry in 1972. At that time, Prof. *E. O. Fischer* was one of the chairs in inorganic chemistry in Munich and *Ulrich Schubert* joined his group for investigations on transition metal carbene complexes which are today the focus of many well-known catalytic active systems. For these studies he was awarded the Ph.D. degree in 1974. During this time *Ulrich Schubert* made probably one of the most exciting personal experiences a scientist can have, because his supervisor Prof. *E. O. Fischer* got the Nobel Prize in chemistry for his work on sandwich-complexes together with *G. Wilkinson* (1973).

Ulrich Schubert continued his scientific career by broadening his knowledge from organometallic towards organic chemistry by joining the group of Prof. *W. S. Johnson* at the Stanford University for a two year lasting postdoctoral stay. Back at the Technical University in Munich, he focused on the combination of preparative organometallic chemistry with the just expanding technique of single crystal X-ray analysis. In 1980 he was awarded to a "Dozent" for inorganic chemistry at the Technical University of Munich, and two years later he moved on the position of a professor for inorganic chemistry to the University of Würzburg, Germany. While still working on transition metal silicon and tin complexes he made first contact with inorganic materials and sol–gel chemistry by collaborating with the Fraunhofer Institute of Silicate (ISC) Research in Würzburg. At this time it was unusual for a professor working on fundamental aspects of organometallic chemistry to get in touch with an institution that focused on applied research. Not only did he establish this cooperation, but he was so successful that he was working in different leading positions at the ISC until he left Würzburg and Germany in 1994 to the Vienna University of Technology (Austria) where he accepted the position of the chair of inorganic chemistry. In the environment of a technically oriented university the transformation to a more applied inorganic chemistry was natural. While *Ulrich Schubert*'s group in Würzburg was focussing 80% on fundamental organometallic chemistry, the ratio changed to nowadays 90% applied inorganic chemistry. Particularly his contributions to sol–gel chemistry, in recent years especially to the transition metal sol–gel chemistry and the formation of metal oxo clusters as building blocks for hybrid materials are internationally well-respected. His success in science is expressed by several hundred publications in scientific journals and many awards, only two of them should be mentioned here: he holds a full membership of the Austrian Academy of Science and a fellowship of the Royal Society of Chemistry. Beside his academic life *Ulrich Schubert* also cared about the perspective of chemistry in the society, for

example in his function as the president of the Gesellschaft Österreichischer Chemiker (GÖCh, Austrian Chemical Society) he invented the very successful Chemistry Week in Austria.

Two things always impressed us in *Ulrich Schubert*'s character, his honesty and his openness for new ideas. Only one phrase should be mentioned here that reflects his open minded character. He once told us when we were discussing the development of a scientific career: ''you should reconsider your achievements in chemistry and change your direction slightly every seven years.''

Dear *Ulrich*, we look forward to see many future scientific seven-year periods with interesting findings in materials chemistry from you and your group.

Happy Birthday!

Guido Kickelbick
Nicola Hüsing
Issue Editors