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Foreword/Avant-propos

The power of synthesis towards new materials☆

Foreword

The First Joint Symposium in Chemistry between the French "Académie des sciences" and the German National Academy of Sciences "Leopoldina" was organized in Halle (Saale, Germany), on 23–24 November 2017, on the topic *The power of synthesis towards new materials*.

Its aims were to promote closer interactions between the two academies and their members by highlighting the central and ubiquitous role of chemical synthesis in the development of new materials relevant to key areas of considerable scientific and societal relevance, ranging from health, electronic materials and catalysis to energy. It also intended to illustrate the importance of fundamental science in the more applied sector. By bringing together 15 highly renowned scientists from France and Germany, most of them were also members of the Academies involved, it was possible to capture most recent and innovative developments occurring in diverse areas of scientific endeavour and promote stimulating discussions.

In his lecture, entitled *The synthesis of future: Inorganic materials meet interface science*, **Matthias Driess** (Technische Universität Berlin) emphasized the steadily growing demand for innovative new materials for energy saving and optimisation in electronic devices. Transparent conducting oxides are key components in organic light-emitting diodes for solar cells, photocatalysts, transparent electrodes in displays and field-effect transistors. By applying the concept of molecular metal-organic single-source precursors, it has been possible to access transparent conducting oxide materials for biofuel cells and clean hydrocarbon catalysis. The lecture also emphasized the key role of low-temperature materials design and synthesis using molecular building blocks for defragmenting catalysis.

Jacques Lucas (University of Rennes) presented how to see beyond the optical limit of 3 μm, associated with the transmission of silica glasses, by introducing heavier elements. *Glasses to see beyond visible* were made by using heavy metal fluorides such as ZrF_4 or sulfur, selenium and tellurium compounds. Because of their unique thermodynamic properties, some of these new materials become plastic solids above the glass transition temperature and then can be moulded or fibred. Optical fibres transmitting light from 2 to 15 μm are used to detect the IR signature of molecules and biomolecules, whereas moulded lenses for infrared cameras are produced for night vision. Impressive industrial developments result from these works.

Stefanie Dehnen (Philipps-Universität Marburg) discussed, in her lecture *Chemistry for materials: From fundamental research and curiosities to useful compounds*, the diversity and tremendous specificity of today's materials. From high-performance catalysts for effective chemical syntheses, new nanoscopic, polymeric and extra robust compounds, innovative materials for energy conversion and data storage, magnets and batteries, to bioactive additives and drugs, the elaboration of new materials requires the chemist's approach.

Thomas F. Fässler (Technical University of Munich) discussed the *Challenges in chemical synthesis for energy storage and energy conversion materials – From bulk alloys to thin films with inverse opal structure*. The formation of small charged atom clusters, which belong to the so-called Zintl ion clusters, obtained by reacting the respective elements with alkali metals provides precursors to a plethora of new compounds. Recent applications for the formation of materials with potential in photovoltaics and as energy storage materials were also illustrated.

Environmental and energy issues have become main challenges for our societies. In his lecture entitled *Building of the future: Challenges in material science*, **Didier Roux** (Saint-Gobain company) showed that buildings have a special position because of the quantitative impact on both energy consumption and the environmental issue. Recent progress has been achieved in the quality of insulation of both wall and glazing. To estimate the efficiency of materials in buildings, it is important to perform quantitative physical measurements on site and in a relatively short lapse of time.

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Sanjay Mathur (University of Cologne) presented a lecture on *Designing catalysts for water-splitting reactions: Oxide–oxide bilayers as high efficiency photoelectrocatalysts through electronically coupled phase boundaries.* Metal oxide nanostructures with hetero-contacts and phase boundaries offer a unique platform for designing materials architectures for energy harvesting applications. As a viable alternative to water electrolysis, photoelectrochemical water splitting has emerged as a competitive technology being capable of converting solar energy directly into chemical energy using stable and efficient photocatalysts for solar hydrogen production. Mathur presented how chemically grown and designed thin films and bilayers of different metal oxides unfold new material properties, which will enter advanced material technologies.

The future of electron correlated oxides was unravelled by **Bernard Raveau** (CNRS–ENSICAEN, Caen). Several new classes of materials have emerged that appear most promising for the generation of attractive physical/chemical properties and applications. Thus, ordered oxygen-deficient perovskites $LnBaCo_2O_{5+\delta}$ display many complex magnetic transitions correlated with electric or dielectric properties. Those exhibiting fast oxygen diffusion and high oxygen storage capacity are promising solid oxide fuel cells (SOFC) cathode materials. Tetrahedral oxygen arrangements in cobaltates (Ln,Ca)$BaCo_4O_7$ and ferrates (Ln,Ca)$BaFe_4O_7$ display an extremely rich magnetism at the origin of attractive multiferroic properties. Other materials were investigated for applications in quantum computing, spintronics and memory devices.

Martin Jansen (Max-Planck-Institut für Festkörperforschung, Stuttgart) illustrated the *Synergies and competition between current approaches to materials discovery.* The approaches developed to access new compounds are based on heuristic concepts like trial and error, including high-throughput techniques, building block assemblies, thermodynamic considerations or crystal chemical rules. This traditional toolbox, has been enriched by various computational techniques during the last decades. Still, most of the breakthroughs continue to be achieved experimentally. A synergetic interplay between experiment and theory appears most promising towards materials discovery.

Bio-inspired nanostructured materials were presented and discussed by **Jacques Livage** (Université Pierre-et-Marie-Curie, Paris). Nature shows that microorganisms such as diatoms are able to build silica shells with highly sophisticated architectures at room temperature. The mild conditions associated with this 'chimie douce' allow the synthesis of hybrid nanocomposites, in which both organic and inorganic phases are mixed at a molecular level. Biomolecules such as enzymes, drugs or antibodies can be immobilized within inorganic silica matrices, opening new possibilities in the field of biotechnology and nanomedicine. Even microorganisms can be trapped within silica glasses, and their retained bioactivity can be used for many applications (biocatalysis, biosensors, bioreactors, drug delivery, etc.).

Patrick Couvreur (Institut Galien, Université Paris-Saclay) discussed *Nanotechnologies for the treatment of severe diseases.* The clinical use and efficacy of conventional chemotherapeutics is hampered by drug resistance at the tissue level and cellular level and by non-specific distribution, biotransformation and rapid clearance of the drugs from the body. The development of nanodevices able to overcome these limitations has become a major challenge. Biodegradable nanoparticles loaded with doxorubicin for the treatment of the resistant hepatocarcinoma have been designed, likewise nanoparticles made of metal oxide frameworks (NanoMOFs). "Multidrug" nanoparticles are able to combine chemotherapy and imaging.

The organizers of this Joint Symposium would like to express their gratitude to the French "Académie des sciences" and the German National Academy of Sciences "Leopoldina" for their financial support, to the Leopoldina for the hospitality and arrangements made in Halle. Of course, it is the quality of the speakers that made this event a scientific success, and we are particularly grateful to those who prepared a manuscript for this special issue of *Comptes rendus Chimie*, thus allowing a broader audience to benefit from their scientific achievements.

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