



LATVIAN ACADEMY OF SCIENCES ACHIEVEMENTS IN SCIENCE 2021

THEORETICAL SCIENCE

I The influence of the local atomic structure of molybdates and tungstates on their thermochromic and magnetic properties is explained.

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Knowledge of the material structure and its dependence on external conditions and composition is important to understand and control the functionality of the material, which ultimately determines its practical applications. In a series of works, a large group of smart materials such as molybdates and tungstates, whose functional properties are closely related to their local atomic structure and chemical composition, has been systematically studied. Using synchrotron radiation sources and high-performance computer modeling, the relationship between the local structure distortion and lattice dynamics of molybdates and their thermochromic properties has been revealed and explained. Moreover, the presence of magnetic dimers has been discovered in tungstates with high nickel content, and their origin was related to the location of nickel ions in the double-well potential. The results obtained demonstrate new possibilities of using X-ray absorption spectroscopy for a study of the structure of functional materials and will help to understand the mechanism of the thermochromic effect, that will open the way for practical applications.

II The first encyclopedia on archeology in the Eastern Baltic region has been published, targeting not only researchers but also the general public.

A. Vasks, G. Zariņa. Handbook of Latvian Archeology (Latvijas arheoloģijas rokasgrāmata). Rīga: Zinātne, 2021, pp. 677, ISBN 978-9934-599-08-8. Institute of Latvian History, University of Latvia.

The “Handbook of Latvian Archeology” is an encyclopedic publication prepared by the Institute of Latvian History of the University of Latvia, which contains concentrated information on Latvian archaeology in all its diversity, based on the latest scientific findings beginning with the late Paleolithic to the 20th century. This is the first encyclopedic publication on the subject of archaeology in the entire Eastern Baltic region, targeting not only the prehistoric research community, but also the general public, students, pupils and museum specialists. A total of 48 authors – archaeologists, paleogeographers, paleobotanists, numismatists, bioarchaeologists and historians from faculties and institutes of the University of Latvia, the Latvian National History Museum, the Latvian Academy of Culture, the National Cultural Heritage Board, the Museum of the History of Riga and Navigation participated in the project.

III A comprehensive study of truth and lies from the perspective of philosophy.

Māris Kūlis. *Finis veritatis? On truth and lies (Finis veritatis? Par patiesību un meliem)*. Rīga: The University of Latvia Press, 2021, pp. 432, ISBN 9789934186479. Institute of Philosophy and Sociology, University of Latvia.

For the first time in Latvia, a comprehensive study on a topical issue – truth and lies – , from the perspective of philosophy, asking how we understand truth and lies. What theories and ideas have emerged, why, from where and where are they leading? It is a story about the emergence of modern science and the resistance to it, about different models of understanding truth – the absolute and the subjective, the timeless and the historical, about changes in the understanding of truth and falsehood that permeate the self-understanding of today’s society. At the same time, however, this story is interwoven with a constant attempt to relate philosophy to the contemporary world, dealing with topics such as politics, advertising, digital technologies,



media power, education, etc. The book is published by the University of Latvia Press. It is a 400-page publication with more than 80 illustrations, which allows the reader to see more clearly the course of philosophical ideas and cultural change. The book's website: www.parpaticiesibu.lv.

IV The Riga Jesuit College library collection in Uppsala has been bibliographically reconstructed and researched in depth.

Gustavs Strenga PhD, Andris Levāns PhD, Laura Kreigere-Liepiņa MA, Reinis Norkārklis MA, Renāte Berga MA. Catalogue of the Rīga Jesuit College Book Collection (1583–1621): history and reconstruction of the collection = Rīgas jezuītu kolēģijas grāmatu krājuma (1583–1621) katalogs: krājuma vēsture un rekonstrukcija. Rīga: National Library of Latvia, 2021, pp. 622.

400 years ago, when the Swedish army occupied Riga, a book collection significant in the history of Latvian culture – the Riga Jesuit College library – was removed to Sweden, where today it forms one of the oldest book collections in the Uppsala University Library. This book collection was bibliographically reconstructed and thoroughly researched. The research discovered publications and copies unique in the context of Latvian and Northern European cultural history. The research results are summarised in the book *Catalogue of the Riga Jesuit College Book Collection (1583–1621): history and reconstruction of the collection*, which includes four research articles, one essay and a catalogue of the collection. Two exhibitions – <https://lnb.lv/en/exhibition-feature-oldest-surviving-book-latvian-language> and <https://www.europeana.eu/en/exhibitions/looted-library-reconstructed-library> – have been organised to highlight the most valuable copies in the collection.

APPLIED SCIENCE

V An innovative, high-speed Thermo-Electric Radiation Sensor (TESS) has been industrialized.

LAS Full member Mārtiņš Rutkis, *Dr.phys.* Kaspars Pudžs, *Dr.phys.* Aivars Vembris, *Mg.phys.* Jānis Busenbergs. Institute of Solid State Physics, University of Latvia Organic Materials Laboratory.

The use of lasers in various fields of technology is inconceivable without precise control of their radiant energy. Current infrared (IR) sensors are not fast enough to record individual laser pulses. To overcome this shortcoming, technology was developed for a high-speed electromagnetic radiation sensor capable of characterizing a very short light pulse shape over a wide spectral range (UV-VIS-IR). The advance of the developed thermoelectric sensor is ensured by the use of innovative materials and technologies.

- ✓ It is 1000 times faster than currently used.
- ✓ The technology can be used, for example, in laser surgical equipment, where its use will permit precise control of the applied radiation energy and thus allow more safe and efficient manipulations.
- ✓ Technology patented in EU, US, Canada and China.
- ✓ Licensing and technology transfer agreement signed with *Thorlabs* GmbH.

VI For the first time in the Baltic States, highly modified bitumen binders and asphalt concrete compositions with high performance characteristics were developed from used car tires and laid on an experimental road section.

Dr.sc.ing. Viktor Haritonov, Rīga Technical University (RTU), Faculty of Civil Engineering, Department of Roads and Bridges; *Dr.sc.ing.* Jānis Zicāns, RTU, Faculty of Materials Science and Applied Chemistry, Institute of Polymer Materials; LAS Corresponding member Remo Merijs-Meri, RTU, Faculty of Materials Science and Applied Chemistry, Department of Polymer Materials Technology; *Mg.iur.* Tīna Lūse, Head of the Latvian Tyre Management Association; *Mg.sc.soc.* Jānis Aizbalts, Chairman of the Management Board of LCC “Eco Baltia vide”; *Mg.sc.soc.* Nauris Bertmanis, LCC “Eco Baltia vide”, Head of the Zemgale branch; *Mg.sc.ing.* Ulvis Rudzis, LLC “Road Construction company IGATE”, Head of Road Construction



Department; *Mg.sc.ing.* Arturs Riekstiņš, Research Management and Development Department, Road Competence Centre, SLLC Latvian State Roads, PhD student at RTU, Faculty of Civil Engineering, Department of Roads and Bridges.

Recycling of used tires remains a global problem. The aim of the project is to develop highly modified bituminous binders and asphalt concrete compositions, using coarsely crushed rubber crumb made from used car tires, and laying these compositions on an experimental section of the road. The possibility of using crumb rubber was assessed by introducing them into bitumen up to 25% using a specially developed technology. The binder thus modified has been found to have a higher degree of elastic recovery as well as improved rutting and cracking resistance compared to the traditional modification. The bitumen binders and asphalt concrete compositions with high performance developed in laboratory conditions were successfully transferred to real production and operational conditions – they were laid on an experimental section of the road with a high proportion of freight transport. This is the first such study in the Baltic States.

VII Development of a method for structural characterization of antigens coupled to virus-like particles in vaccine formulations.

LAS Full member Kristaps Jaudzems, *Mg.biol.* Anna Kiršteina, *Mg.chem.* Jānis Bogans, *Dr.biol.* Andris Kazāks, LAS Full Member Kaspars Tārs. Latvian Institute of Organic Synthesis, Latvian Biomedical Research and Study Center.

Methods that make it possible to see molecules with atomic resolution have had a major impact on the development of various fields related to molecular sciences. Vaccine development often relies on an approach in which the antigen is coupled to adjuvants – substances that enhance the immune response. However, the coupling of the antigen with the adjuvants is not always successful and it is necessary to verify that the structure of the antigen remains intact after the coupling onto the surface of the adjuvant. Researchers from the Latvian Institute of Organic Synthesis and the Latvian Biomedical Research and Study Center, in collaboration with the University of Aix-Marseille and the University of Lyon in France, have developed a new method for observing antigen molecules at atomic resolution and characterizing their structure when coupled to virus-like particles as adjuvants. The method will facilitate the design of vaccines, as well as their formulation and production method development.

VIII Electrosynthesis solves a long-standing scientific challenge and opens the door to valuable chemical reagents.

Dr.chem. Igors Sokolovs, LAS Full member Edgars Sūna. Latvian Institute of Organic Synthesis.

Organic electrosynthesis has received growing attention and interest recently and it is frequently referred to as “future chemistry”. In the electrosynthesis, electric current is used instead of a chemical reagent. Key advantages of electrosynthesis as compared to traditional organic synthesis methods are i) considerable cost reduction (the current required to produce one kilogram of a substance costs less than a Euro cent), ii) significantly reduced environmental impact (the current does not produce harmful chemical by-products and waste) and high safety (the method does not employ toxic chemical reagents). Researchers from the Latvian Institute of Organic Synthesis in collaboration with scientists from Rostock University (Germany) have successfully employed organic electrosynthesis to solve a long-standing challenge of obtaining valuable bromine-containing chemical reagents. Until now, lack of convenient methods for their synthesis has hampered wide use of the bromine-containing chemical reagents in organic synthesis, drug discovery and the development of smart materials.

IX Conversion of biomass waste into sustainable bioplastic products.

Dr.sc.ing. Sergejs Gaidukovs, *Mg.sc.ing.* Oskars Platnieks, *Mg.sc.ing.* Anda Barkāne, *Mg.sc.ing.* Sergejs Beļuns, *Dr.sc.ing.* Gerda Gaidukova, Riga Technical University, Institute of Polymer Materials, *Dr.sc.ing.*



Inese Filipova, Latvian State Institute of Wood Chemistry (cooperation partner), *Dr.phys.* Olesja Starkova, Institute for Mechanics of Materials, University of Latvia (cooperation partner).

Plastic waste recycling has become one of the major challenges of the 21st century. Bio-based plastics account for an increasing share of the global market. Complex polymer systems and soft matter Institute of Polymer Materials, Faculty of Materials Science and Applied Chemistry, Riga Technical University has developed plastic materials of biological origin to solve sustainability issues and maintain a clean, unpolluted environment. The possibility to produce biodegradable plastics from renewable forestry and agricultural biomass, their waste and production by-products has been developed. The range of potential applications covered includes wood-mimicking plastics, thermal insulation materials, 3D printing inks and resins, packaging and agricultural materials. The use of wood chips, agricultural hemp straw, and other low-cost residual products can reduce costs, improve mechanical, gas and water barrier properties, and accelerate the decomposition of materials in the soil or landfill. Consumer packaging materials, thermal insulation materials, 3D printing inks, and wood-mimicking products are just a few of the industries that could benefit from the bioplastic materials being developed. The widespread production and use of such materials could significantly reduce pollution and contribute to the economy by creating value-added products.

X New technologies and economically viable solutions for local feed production for pig farming.

Dr.agr. Sanita Zute, *Dr.sc.ing.* Vita Šterna, *Dr.agr.* Imants Jansons, *Dr.agr.* Inga Jansone, *Dr.agr.* Māra Bleidere, Institute of Agricultural Resources and Economics, *Dr.agr.* Lilija Degola, Latvia University of Life Science and Technologies, *Dr.oec.* Andris Miglavs, *Dr.oec.* Alberts Auziņš, *Dr.oec.* Agnese Krieviņa, *Mg.sc.soc.* Ieva Leimane, LLC “EDO Consult”.

For the first time in Latvia, an interdisciplinary study has been conducted on the effective expansion of the local feed production market, evaluating the possibilities of soy cultivation and use in Latvian conditions in order to reduce the dependence of the pig industry on imported protein feed. The study comprehensively analyzes the technological and economic side of local fodder production, including the contribution of various legumes and cereals, especially soybeans and hull-less barley, to the production of high-quality feed made from local resources. Private crop and feed production, pig breeding companies are involved in the implementation of the research, implementing various experiments in industrial conditions in the regions of Latvia. The results have been compiled in nine publications in scientific journals indexed in the SCOPUS database, and six other scientific publications, guidelines for industry companies have been compiled in a virtual book.

XI For the first time the occurrence of several groups of halogenated persistent organic pollutants in environmental objects and food products in the Baltic Sea region was studied.

Dr.chem. Dzintars Začs, *Dr.chem.* Ingus Pērkons, Elīna Pasečnaja, Eļnora Abdulajeva, *Dr.chem.* Vadims Bartkevičs, *Dr.chem.* Arturs Vīksna. Institute of Food Safety, Animal Health and Environment “BIOR”.

For the first time the occurrence of several groups of halogenated persistent organic pollutants (POPs) in environmental objects and food products in the Baltic Sea region was studied. Several innovative sensitive and selective analytical methods and strategies for POP analysis in complex matrices were developed. Several data sets on the contamination of environmental objects and foodstuffs with different POPs groups were created. The presence of POPs was detected in all studied objects, while unexpectedly high concentrations were also found in the food for infants and young children. The results of the research have been summarized in 12 high-quality publications which were published in international scientific journals and included in leading databases.