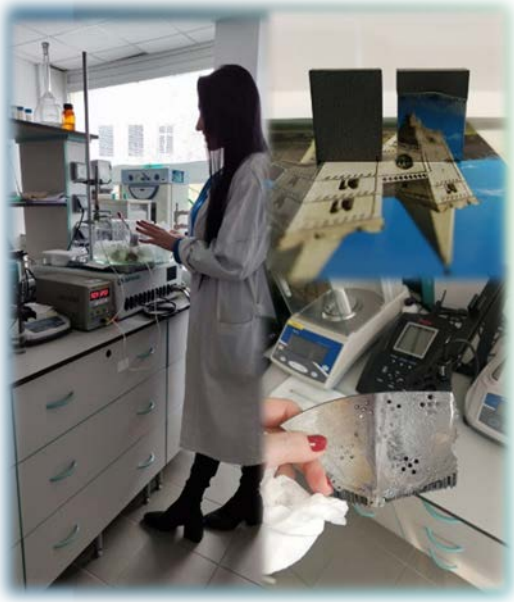
Scientists from the Institute of Inorganic Chemistry SAS (IIC SAS) became leaders in applied science, achieved success in cooperation with industry and paved the way for the further transfer of intellectual property at the national and international level

The beginning of this success story was the application of the project "**NanoBioFit – Nanostructured, functionally graded, and bioinspired 3D Ti-based implants**" by the team of authors of the department of ceramics of IIC SAS in APVV call 2021. The mentioned project was based on the close cooperation of the leading researchers of the IIC SAS in various fields (experts in inorganic chemistry, ceramic materials, electrochemistry, etc.) with Biomedical Engineering Company (Kosice, Slovak Republic), which is a leader in the production of titanium prostheses and implants using 3D printing technology. Ambitious plans and real tasks set by the industrial partner allowed to obtain funding and start productive work on the implementation of the project.

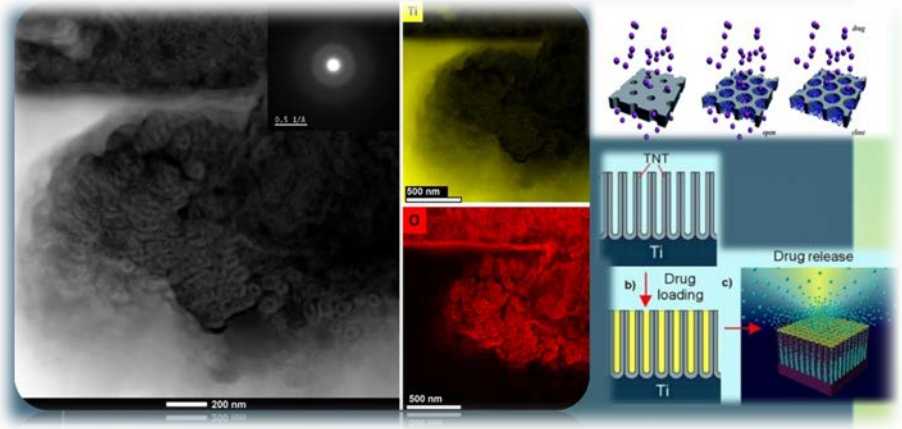


For decades, attempts have been made to improve the surface properties and bioactivity of titanium prostheses and implants in order to reduce the number of failures in implantation practice and shorten the healing period. Despite some progress in the field of surface modification of titanium products, the search for effective, affordable, fast and cheap solutions remained an urgent task. The most common titanium processing technique, sandblasting, has shown significant disadvantages for biomedical applications caused by contamination of the surface with blasting particles. In this regard, manufacturers of prostheses and implants and researchers were

faced with the task of obtaining a non-contaminated surface, with an improved wettability, high corrosion resistance and sufficiently high biocompatibility. All these requirements were met by the new developed technology of the electrochemical surface treatment of titanium and its alloys in environmentally friendly deep eutectic solvents.

Assoc. prof. Mgr. Anna Kityk, PhD and Assoc. prof. Ing. Miroslav Hnatko, PhD became the idea authors and creators of this technology. The new generation solvents, deep eutectic mixtures, were chosen due to their numerous advantages over aqueous and non-aqueous systems. The main attractive characteristics of a new class of solvents are ability to biodegrade (100% biodegradation by bacteria and fungi in the natural environment during 28 days), high thermal, chemical and electrochemical stability, neutral pH, low corrosivity, which ensures safety for both human and the environment. An advantageous combination of physicochemical properties of new electrolytes allows efficiently and flexibly modeling the surface properties of the titanium products. It should be emphasized that electrochemical treatment in deep eutectic solvents does not require toxic additives, high or low temperatures, as was the case with the anodization of titanium in previously proposed and patented electrolytes. Availability and relative cheapness of components, efficiency and ease of processing allow the new technology to become a promising alternative to the “classical” methods of processing titanium and its alloys.

The possibility of micro- and nanoengineering of a titanium-based surfaces using the proposed technology deserves special attention. Development of micropores, nanopores and nanotubes



is possible in deep eutectic solvents. Drug delivery, surface modification with biomolecules and hydroxyapatite can be moved to a new level with proposed micro and nano leveling. The creation of a combined hierarchical micro and nano structure (similar to real bone tissue) on the surface of prostheses and implants allows to significantly increase the cell attachment and growth and, thus, improve biocompatibility.

Obvious progress and achievements in the implementation of the project and the solution of existing research tasks were noted by the industrial partner. Besides, the results obtained became the basis of two European and one International patent applications.

- **European patent application entitled "Method for electrochemical surface treatment of biomedical products made of titanium or Ti-based alloys" was registered under the number 22193733.7 (2.09.2022).**
- **European patent application entitled “A method for electrochemical surface treatment of biomedical products made of titanium or Ti-based alloys” was registered under the number 22204696.3 (31.10.2022).**
- **International patent application entitled “A method for electrochemical surface treatment of biomedical products made of titanium or Ti-based alloys” was registered under the number PCT/SK2023/050006 (12.04.2023).**

The presentation of the results at the international forum organized by Taiwan showed a significant interest in the achieved outcomes. The new technology has also attracted the interest of local manufacturers. As a result of a joint meeting and negotiations, a cooperation agreement was signed with the company MIKROCHEM GROUP (Slovak Republic), which is manufacturer and R&D of new active pharmaceutical ingredients of new medicine and treatments, that can save lives and have a positive impact in the society.

Technology Transfer Office SAS nominated innovation of A. Kityk and M. Hnatko and their team for the "Technology Transfer Award in Slovakia 2023" competition, in 2 categories: "innovation" and "innovators".

Some additional information can be found on the web pages of Technology Transfer Office SAS:

https://ktt.sav.sk/povrchova-uprava-biomedicinskeho-titanu-a-ti-zliatin/

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