

Multifunctional Bioactive Biomaterials for Local Therapy and Tissue Regeneration: *From passive medical materials to active therapeutic interfaces*



Description: The innovation comprises a family of multifunctional biomaterials developed to transform conventional passive medical materials into active therapeutic systems capable of interacting with their biological environment.

The presented portfolio includes inventions for dental, orthopaedic and reconstructive applications. Despite the diversity of the target medical devices, the solutions share a common technological concept: the functional modification of biomaterial surfaces or fillers to introduce additional biological functions, including local drug delivery, antibacterial activity, remineralisation and support of tissue–implant integration.

The developed technologies can be applied to different classes of biomaterials, including titanium, polyester and polypropylene implants, as well as resin-based dental composites. Depending on the clinical application, specially designed bioactive layers or fillers incorporating metal ions, polyphenolic compounds, phosphates, phytates or zeolites are used to bind and locally deliver therapeutic agents or biologically active ions.

In dental applications, the developed solutions include antibacterial composites designed for local antibiotic delivery at the tooth–restoration interface, as well as remineralising composites capable of releasing calcium and fluoride ions in areas particularly susceptible to secondary caries.

For orthopaedic and dental implants, functionalised titanium surfaces combine local therapeutic activity with bioactive components designed to support osseointegration. The same general concept has also been extended to polymer-based artificial tendons and ligaments and to reconstructive implants, where surface modification enables antibacterial activity and the controlled local release of antibiotics.

The key innovation is therefore not a single coating or material composition, but a versatile technological strategy for engineering the interface between an implanted material and the human body. By selecting the biomaterial substrate, functional layer,

bioactive ions and therapeutic compound, the technology can be adapted to different clinical needs and applications.

The developed solutions are intended to reduce the risk of implant-associated infections, decrease the need for systemic drug administration, support tissue regeneration and improve the long-term functionality of medical biomaterials.

The concept is supported by a growing portfolio of patents and patent applications and demonstrates a continuous development pathway from functional dental composites to multifunctional metallic and polymeric implants.

Organisation: Poznan University of Technology

Innovator(s): Mariusz Sandomierski, Zuzanna Buchwald, Marcel Jakubowski, Jakub Reczkowski, Aleksandra Domke, Monika Zielińska, Adam Voelkel, Kuba Mularski, Ewa Rosińska, Gabriela Ryś, Martyna Maria Pruszkowska-Barszcz, Kamila Czerniak, Katarzyna Hałas

Category: Medicine, Biotechnology and Medical Devices

Country: Poland

Video: <https://www.youtube.com/embed/7JUj7m7C0jg>

Multifunctional Bioactive Biomaterials for Local Therapy and Tissue Regeneration: *From passive medical materials to active therapeutic interfaces*

Innovators: Mariusz Sandomierski^{P1,P2,P3,P4,P5,P6,P7,P8,P9,P10,P11}, Zuzanna Buchwald^{P2,P3,P11}, Marcel Jakubowski^{P2,P3,P5,P6,P9,P10,P11}, Jakub Reczkowski^{P4,P7,P8,P9}, Aleksandra Domke^{P2,P3,P11}, Monika Zielińska^{P1,P6,P7,P8,P9}, Adam Voelkel^{P1,P2,P3,P4,P5}, Kuba Mularski^{P6}, Ewa Rosińska^{P7}, Gabriela Ryś^{P7}, Martyna Maria Pruszkowska-Barszcz^{P8}, Kamila Czerniak^{P9}, Katarzyna Hałas^{P5}

Inventions Included in the Portfolio

The portfolio includes 11 inventions covering functionalised titanium and polymeric implants, artificial tendons and ligaments, reconstructive implants, and antibacterial or remineralising dental composites.

P1 *Titanium material for an implant and method for its production*, M.S., M.Z., A.V., GRANTED PATENT, Pat.242080 RIGHTS TRANSFERRED TO INDUSTRY, Endomedic sp. z o.o., 2026.

P2 *Method of manufacturing a dental composite with an antibiotic-loaded filler*, Z.B., A.D., M.J., A.V., M. S. GRANTED PATENT, Pat.248962.

P3 *Method for manufacturing dental composites with phytate fillers with remineralization potential*, Z.B., A.D., M. J., A.V., M.S. PUBLISHED PATENT APPLICATION, P.449860.

P4 *Method of producing polyester material for artificial tendon*, M.S., J.R., A.V., PUBLISHED PATENT APPLICATION, P.450394. AWARD-WINNING INVENTION.

P5 *Titanium material modified with a zinc-doped polyphenol layer for use in orthopedic and dental implants and method for producing the same*, M.S., K.H., M.J., A.V., PUBLISHED PATENT APPLICATION, P.449138. AWARD-WINNING INVENTION.

P6 *Method for producing a modified titanium material for orthopaedic or dental implants*, M.J., M.Z., K.M., M.S. PATENT APPLICATION, P.453635.

P7 *Method for producing an antibiotic-releasing polyester material for an artificial ligament*, J.R., M.S., E.R., G.R., M.Z. PATENT APPLICATION, P.455221.

P8 *Method for producing an antibacterial polyester material for an artificial ligament*, J.R., M.M.P.-B., M.Z., M.S. PATENT APPLICATION, P.453789.

P9 *Method for producing a polypropylene material capable of antibiotic sorption and release for an orbital reconstruction implant*, J.R., M.J., K.C., M.Z., M.S., PATENT APPLICATION, P.455510.

P10 *Method for producing titanium material modified with a titanium phosphate layer doped with bioactive ions for an orthopaedic implant*, M.S., M.J., PATENT APPLICATION, P.452788.

P11 *Dental composite material and method for its production*, Z.B., A.D., M.J., M.S., PATENT APPLICATION P.456084

Introduction

Conventional biomaterials mainly provide structural functions, while infections, biofilm formation, limited tissue integration and systemic drug administration remain major clinical challenges. The inventions transform passive biomaterials into multifunctional materials with local therapeutic and biological functions.

Technology Description

The common concept is the functional modification of biomaterial surfaces or fillers to introduce local therapeutic and bioactive functions. The technologies apply to titanium, polyester, polypropylene and dental composites. Functional layers or fillers enable local delivery of therapeutic agents or bioactive ions. Depending on the application, they provide antibacterial activity, controlled drug release, remineralisation or support of osseointegration.

Key Advantages

- local therapeutic action,
- controlled delivery of active substances,
- antibacterial and antibiofilm activity,
- reduced need for systemic drug administration,

- support of remineralisation and osseointegration,
- applicability to different biomaterials,
- simple and adaptable modification methods.

AWARDS

Special Jury Award – “New Generation of Innovators” The invention “*Titanium material modified with a zinc-doped polyphenol layer for use in orthopedic and dental implants and method for producing the same*” received the Special Jury Award “New Generation of Innovators” in the 13th edition of the **Eureka! DGP – Discovering Polish Inventions** competition.

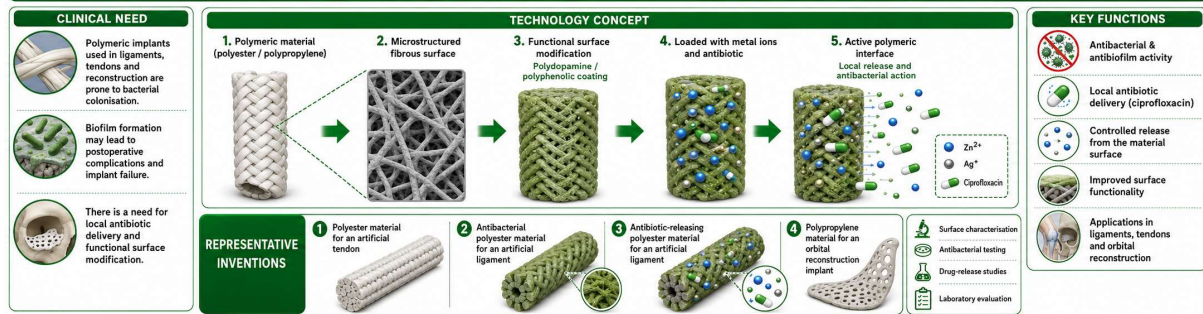
Jakub Reczkowski received the Marshal of the Świętokrzyskie Voivodeship Award in the national Student-Inventor competition for the invention “Method of producing polyester material for artificial tendon”. The same invention also received a **Silver Medal at the International Warsaw Invention Show (IWIS 2025)**, held in Warsaw in 2025.

Science–Industry Cooperation

In March 2026, the rights to Polish Patent Pat.242080 – “*Titanium material for an implant and method for its production*” were sold to **Endomedic sp. z o.o.**, demonstrating the commercial potential of the developed biomaterial technologies and successful transfer from academic research to industry. Potential partners include companies developing dental materials, implants, reconstructive devices and local drug-delivery systems. Cooperation may include optimisation, scale-up, prototyping, testing, licensing and commercialisation. We are open to cooperation with industrial partners interested in multifunctional medical materials.

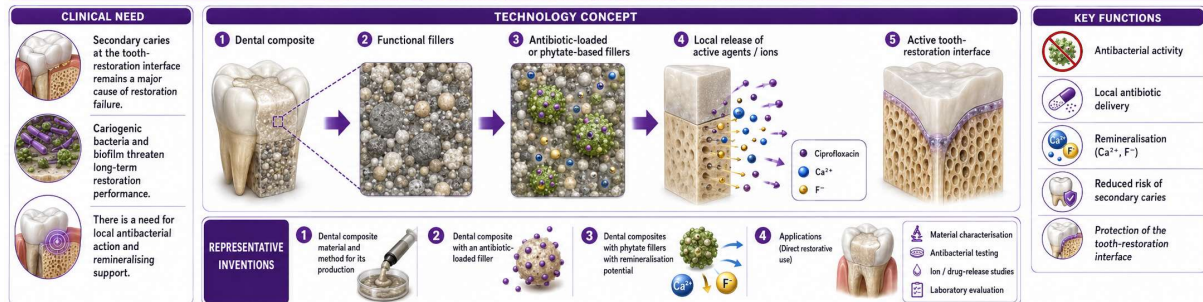


2. FUNCTIONAL POLYMERIC MATERIALS FOR LOCAL DRUG DELIVERY, INFECTION CONTROL AND RECONSTRUCTION



FUNCTIONAL POLYMERIC SURFACES. LOCAL ANTIBIOTIC DELIVERY. RECONSTRUCTIVE APPLICATIONS.

3. ACTIVE DENTAL COMPOSITES FOR ANTIBACTERIAL PROTECTION AND REMINERALISATION



ACTIVE DENTAL COMPOSITES. LOCAL PROTECTION. REMINERALISING FUNCTION.