Univerza v Mariboru

FRAMEWORK PROGRAMME OF EARLY STAGE RESEARCHER TRAINING[1]

1. BASIC DATA

Mentor's name and surname	Zoran Novak	Mentor's register number at ARIS (SICRIS):	**13568**
Mentor's e-mail:	zoran.novak@um.si	Mentor's tel. no.:	02 2294 402
Research programme (RP) leader's name and surname:	Željko Knez	RP leader's register number at ARIS (SICRIS):	02619
Title of research programme:	Separation processes and product design	RP's Register number at ARIS (SICRIS):	P2-0046
Research organisation (RO) of University of Maribor, where training shall be conducted:	Faculty of Chemistry and Chemical Engineering	RO Register number at ARIS (SICRIS):	0552-0794
Research field according to ARIS classification:	2.02 Chemical Engineering	Research field according to Ortelius classification (EURAXESS)	37.2 Chemical Engineering

2. DEFINITION OF RESEARCH PROBLEM AND GOALS OF DOCTORAL RESEARCH[2]

Starting point of research task of the early stage researcher and its position in the research programme, where the mentor is included, work hypothesis, research goals and foreseen result with emphasis on an original contribution to science:

Background and hypotheses

The global population is ageing rapidly. According to the World Health Organization (WHO, October 2021), the world's population aged 60 and above will reach a share of 22% of the total world population in 2050. By 2100 this number is expected to increase to 31.3%. The statistical office of the Republic of Slovenia (SURS) reports in the Slovenian Development Strategy 2030 that the ageing process in Slovenia will continue to accelerate, and the share of the population over 65 will reach

[1] *Term early stage researcher (ESR) is written in male form and used as neutral for women and men.*

[2] *Research and study programme of training have to harmonise with contents of the research programme, where the mentor is a member.*

30% in 2060. With increasing age, the burden of orthopaedic and cardiovascular diseases is rising, creating a need for medical implants and thus driving the market's growth. Bone implants are medical devices that replace missing joints or bones or support a damaged bone. Bone is the second-most transplanted tissue worldwide. Therefore, orthopaedic implants are expected to hold a significant market share in the medical implants market.

The most used materials for orthopaedic implants are synthetic (metal, calcium phosphate ceramics, bioglasses). Their main drawbacks are their short durability, incomplete integration, and even rejection by the body. Metal implants often require secondary surgical removal (due to implant migration, discomfort, or pain).

In addition, ensuring the safety and performance of medical devices, such as bone implants, is a critical priority that EUR-Lex recognizes. This presents an excellent opportunity for introducing biomaterial technology and bio-based materials into the bone implant field. New materials should provide solutions to enhance the quality of life and well-being and stop the current exponential growth in health care costs (hospitalization, sick leave, and in-home health care).

The aim of the programme would be the formulation of new bio-based composites using a completely new class of materials (e.g. bio-aerogels) and special supercritical fluid technology. Supercritical technology is showing high potential in the future development and production of bone implants. This technology allows us to produce implants with improved mechanical properties, increased biocompatibility and reduced toxicity compared to traditional implant materials. The supercritical process can also be used to modify the surface of implants to enhance bone ingrowth and improve long-term implant stability. Aerogels are low-density, highly porous materials obtained after supercritical drying, and they have been explored as potential materials for bone implants. They have several properties that make them appealing for medical applications, including high porosity, low thermal conductivity, low density and biocompatibility. Additionally, they can be customized to meet specific mechanical and biological requirements such as strength and osteoconductivity.

Objectives

The objective of the proposed programme is the formulation and design of novel **bio-based organic solvent-free polysaccharide aerogels and their composites with different polymeric foams** as biodegradable scaffolds for bone implants to treat large bone defects and:

- To develop the preparation and gelation methods of polysaccharides (e.g. chitosan xanthan, alginate, pectin, ...) and biodegradable polymers (e.g. PCL, PLA) in order to obtain stable gels
- To optimize the method of drying of gels (static, dynamic)
- To develop macroporous foams that will enable stable incorporation of aerogels into their pores
- To develop solvent-free aerogels and aerogel/foams
- To remove solvents from wet gels without collapsing their structure
- To design new scaffold materials with desired structural and mechanical properties
- To achieve the controlled and prolonged release of anti-inflammatory and antimicrobial agents from aerogels and aerogel/foams
- To design a formulation and potential applications of developed nanostructured materials for bone implants

Expected results

The research programme will lead to the composite material of which macropores are filled with materials with nano and mesoporous structures. The resulting composites will have good mechanical and structural properties, suitable for use in biomedical applications. Anti-inflammatory and antimicrobial agents will be incorporated into aerogels and aerogel/foams in order to achieve local controlled and prolonged release of the bioactive agents. This approach provides better clinical outcome, less risk for implant rejection, less need for postoperative intravenous treatment and better patient compliance. Cell toxicity and degradation rates will be determined in order to achieve degradation rates similar to the new bone formation.

The proposed research program will be part of the framework of the research programme P2-0049 Separation processes and product design, where the research of biodegradable and biocompatible materials (e.g. aerogels, polymeric foams,...) are one of the important parts. The proposed research is directly addressing one of the current main European challenges (active ageing) and is in agreement with Slovenia's smart specialisation strategy S4 (materials, nanotechnology, health & medicine) and with European Commission Strategic Plan 2020-2024 Health&Food Safety (antimicrobial resistance).

3. STUDY PROGRAMME

Foreseen study programme, to which early stage researcher shall be enrolled in academic year 2025/2026:

Doctoral study program Chemistry and Chemical Engineering at FKKT UM

4. DESCRIPTION OF WORK AND TASKS

Implements scientific and research projects.
Participates in design of research programmes.
Works professionally with research clients.
Prepares research reports and studies.
Monitors and coordinates research work in accordance with funding agreements.
Ensure safe and healthy working conditions.
Organises and instructs staff and students in the use of personal protective equipment and other safety measures.
Performs other related duties as directed by employee's line manager.
Participates in working and standing committees of the UM and its members.
Replaces colleagues and supervisor in their absence (by mandate).
Participates in annual and other inventories.
Performs other related work as assigned by superiors.

5. REQUESTED LEVEL OF EDUCATION

VII/2. tariff group

6. REQUESTED FIELD OF EDUCATION

Tehnical, Natural science

7. KLASIUS SRV

Seventh level: Second cycle of higher and similar education/Second cycle of higher and similar education

8. KLASIUS P

4 - Natural science, mathematics and computing
5 - Engineering, manufacturing and construction

9. REQUESTED KNOWLEDGE

Computer skills: MS Windows, Word, Excel, Internet, e-mail, e-commerce

10. REQUESTED SPECIAL REQUIREMENTS

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11. REQUESTED LANGUAGES

Active knowledge of one world language

12. REQUESTED WORK EXPERIENCE

/

13. FORESEEN POSTDOCTORAL TRAINING

Kliknite ali tapnite tukaj, če želite vnesti besedilo.

Mentor's signature:

ZORAN NOVAK Digitally signed by ZORAN NOVAK
Date: 2025.02.03 10:53:38 +01'00'

Research programme leader's signature:

Željko Knez Digitally signed by Željko Knez
Date: 2025.02.03 11:24:53 +01'00'

Name and surname of Dean or authorised person[3]:
Prof.dr. Zoran Novak

Signature of dean or authorised person:

ZORAN NOVAK Digitally signed by ZORAN NOVAK
Date: 2025.02.03 11:46:03 +01'00'

Place and date:

Maribor 30.01.2025

Kliknite ali tapnite tukaj, če želite vnesti datum.

Stamp:

[3] The training program is signed by the dean of the member where the ESR's employment and training will take place.