PHD PROJECT DESCRIPTION
(4000 characters max., including the aims and work plan to de published online)

Project title: Design of smart biomaterials supporting skin regeneration and wound heling

1.1. Project goals

The project aims to develop innovative smart polymeric materials for biomedical applications. The main objective is to create a smart wound dressing that not only provides protection but also actively supports skin regeneration and wound healing.

1.2. Outline

1. Synthesis and characterization of the material as a biopolymer matrix intended for skin contact
2. Modification of the polymer matrix using natural crosslinking agents
3. Incorporation of bioactive substances supporting the skin regeneration, particulary wound healing
4. Physicochemical characterization of the developed materials
5. Evaluation of their biological properties

1.3. Work plan

1. Material design and synthesis:
- Synthesis of base matrices intended for skin contact
- Initial optimization of composition and processing parameters
2. Functionalization and modification:
- Incorporation of natural crosslinking agents to enhance stability and biocompatibility
- Introduction of bioactive compounds supporting skin regeneration and wound healing
3. Physicochemical characterization
- mechanical testing
- Swelling behavior and degradation studies
- Structural and morphological analysis
- Evaluation of pH-responsiveness and controlled release properties
4. Biological evaluation:
- Cytocompatibility studies using relevant skin cell lines (e.g., fibroblasts, keratinocytes)
- Assessment of wound healing potential
- Evaluation of antimicrobial activity
- Analysis of antioxidant properties and ROS modulation.

1.4. Literature (max. 7 listed as a suggestion for a PhD candidate preliminary study)

1. Zasada Lidia et al., Matrix-dependent effects of phytic acid on konjac glucomannan and

hyaluronic acid films for biomedical applications, Journal of Biomedical Materials Research Part A 114 (2026) e70056
2. Kaczmarek-Szczepańska Beata et al., Development and characterization of biocompatible chitosan-aloe vera films functionalized with gluconolactone and sorbitol for advanced wound healing applications, ACS Applied Materials & Interfaces, American Chemical Society 17 (2025) 15196-15207
3. Grabska-Zielińska Sylwia et al., Dialdehyde alginate as a crosslinker for chitosan/starch films : toward biocompatible and antioxidant wound dressing materials, International Journal of Molecular Sciences 27 (2026) 1174
4. Antonowicz-Hüpsch et al., Multifunctional cellulose acetate : based composites incorporating green-synthetized silver nanoparticles and cinnamon extract for biomedical wound dressing applications, Carbohydrate Polymer Technologies and Applications 14 (2026) 101133
5. Kaczmarek-Szczepańska Beata et al., Journal of Functional Biomaterials 14 (2023) 69
6. Kozłowska Justyna et al., Gelatin and gelatin/starch-based films modified with sorbitol for wound healing, Journal of the Mechanical Behavior of Biomedical Materials 148 (2023) 106205
7. Kaczmarek-Szczepańska Beata et al., The characterization of collagen-based scaffolds modified with phenolic acids for tissue engineering application, Scientific Reports 13 (2023) 1-12

1.5. Required initial knowledge and skills of the PhD candidate

The candidate should possess a solid academic background in materials science, chemistry, biotechnology, biomedical engineering, or a related field. A Master's degree (or equivalent) in one of these disciplines is required. Essential knowledge and skills include:
- Fundamental understanding of polymer science and biomaterials
- Basic knowledge of cell biology and microbiology, especially in the context of skin physiology and wound healing
- Familiarity with laboratory techniques, including material synthesis
- Understanding of analytical methods such as FTIR, SEM, or mechanical testing is desirable
- Ability to analyze and interpret scientific data
- Good command of English (written and spoken) sufficient for scientific communication
- Strong motivation for research, critical thinking, and ability to work both independently and in a team

1.6. Expected development of the PhD candidate's knowledge and skills

During the PhD project, the candidate is expected to significantly expand their interdisciplinary expertise, combining materials science with biological and biomedical applications. The expected development includes:
- Advanced knowledge in design and fabrication of smart biomaterials, including responsive and multifunctional hydrogel systems
- In-depth understanding of skin biology, wound healing processes, and microbiome interactions
- Practical skills in advanced physicochemical characterization techniques (e.g., rheology, spectroscopy, microscopy)
- Expertise in biological evaluation of biomaterials, including cytocompatibility, antimicrobial

activity, and regenerative potential
- Ability to design and conduct complex experimental studies, including data integration from multiple disciplines
- Development of scientific writing and publication skills, leading to high-quality peer-reviewed articles
- Experience in presenting research at international conferences and scientific meetings
- Strengthening of critical thinking, problem-solving, and innovation-oriented research approaches