# 1. PHD PROJECT DESCRIPTION (4000 characters max., including the aims and work plan)

**Project title:** Design of hydrogel and sponge dressings based on polysaccharides crosslinked with plant extracts

## 1.1. Project goals

- obtain novel materials in form of hydrogels and sponges based on chosen polysaccharides;
- evaluation of physicochemical and biological properties of obtained materials;
- the improvement of antibacterial and antioxidative properties of formed materials;
- the formation of materials with potential applications as efficient biodegradable wound dressings.

#### 1.2. Outline

Modern wound dressings based on biodegradable hydrogels and sponges are highly effective in wound healing due to their ability to maintain an optimal moist environment, support natural regeneration, and minimize environmental impact. Hydrogels create a humid microenvironment that accelerates cell migration, reduces necrotic tissue formation, and enables gentle autolytic debridement. Sponge dressings, especially those made from biodegradable polysaccharides such as alginate or chitosan, are highly absorbent, efficiently managing wound exudate and protecting the surrounding skin from maceration, while also providing cushioning and mechanical protection. The use of biodegradable materials ensures that, after fulfilling their function, these dressings naturally degrade, significantly reducing medical waste and the ecological footprint of wound care. Clinical studies show that both hydrogel and sponge dressings reduce inflammation and scarring in burns compared to traditional methods. In chronic wounds, such as pressure ulcers, they shorten healing time by stimulating angiogenesis and effectively managing exudate. Both types are well-tolerated by tissues, minimizing pain and trauma during dressing changes. Hydrogels offer cooling and non-adherent properties, which further increase patient comfort, while sponges adapt to various wound shapes and provide additional support. Moreover, both hydrogel and sponge dressings are biocompatible and mimic the extracellular matrix, further supporting the natural healing processes. Their biodegradability, combined with high therapeutic efficacy, makes them an innovative and patient-friendly alternative to traditional dressings, allowing for tailored wound care and contributing to more sustainable medical practices..

Summarizing designing biodegradable hydrogel and sponge dressings is extremely important because it combines clinical benefits with environmental responsibility. Such dressings effectively support the wound healing process by providing optimal moisture conditions, protection against infection, and patient comfort. At the same time, thanks to their biodegradability, they naturally decompose after use, significantly reducing medical waste and their negative impact on the environment.

#### 1.3. Work plan

The main goal will be achieved through the implementation of working elements as follows:

Task 1: Material selection and crosslinking using agents derived from plant extracts.

Task 2. Development of a sponge-forming method from solution and freeze-drying processes

Task 3: Physicochemical characterization of prepared materials by different methods, e.g., ATR-FTIR, mechanical testing, contact angle measurement, AFM, swelling/degradation tests, thermal properties, aging tests,

Task 4: Conducting biological studies – in vitro biocompatibility testing.

Task 5: Selection of the most promising wound dressing material.

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

Yu Zhang, et al, *Advances in the study of polysaccharide-based hydrogel wound dressings*, International Journal of Biological Macromolecules 307 (2025) 142134

Xuehao Tian, et. Al. *Recent advances in smart hydrogels derived from polysaccharides and their applications for wound dressing and healing*, Biomaterials 318 (2025) 123134

Chao Ma, et al. A review of polysaccharide hydrogels as materials for skin repair and wound dressing: Construction, functionalization and challenges International Journal of Biological Macromolecules 280 (2024) 135838

Huan Cheng, et al. *Facile preparation of polysaccharide-based sponges and their potential application in wound dressing*, Journal of Materials Chemistry B ,2018, 6,634

Huiqing Xu et al. *Research progress of natural polysaccharide-based and natural protein-based hydrogels for bacteria-infected wound healing*. Chemical Engineering Journal 496 (2024) 153803

Chuan Tang et al. *Preparation and characterization of chitosan/sodium cellulose sulfate/ silver nanoparticles composite films for wound dressing.* Materials Today Communications 33 (2022) 104192

Georgia Michailidou et al. Super-hydrophilic and high strength polymeric foam dressings of modified chitosan blends for topical wound delivery of chloramphenicol, Carbohydrate Polymers 208 (2019) 1-13

## 1.4. Required initial knowledge and skills of the PhD candidate

- Analytical thinking
- Eager to learn
- Knowledge about polymers
- Knowledge about materials characterization
- Basic knowledge about polymers modification

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

Acquiring advanced skills in analyzing materials

- Learning advanced instrumental techniques
- Learning techniques of the laboratory work
- Learning biological research techniques
- Development of analytical thinking
- Personal development as a young scientist