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

Project title: Development and characteristics of polysaccharides-based composites as materials for biomedical and/or cosmetic applications

1.1. Project goals

The primary purposes of this project are:

- To use selected ionic liquids and deep eutectic solvents to prepare polysaccharide composites in the form of thin films and 3D porous structures
- To improve the thermal stability and physical properties in polysaccharide composites
- To identify composition variants with enhanced physicochemical and biological properties compared to the selected parent compounds

1.2. Outline

Natural polysaccharides are widely used in the cosmetic industry as raw materials and show significant promise for biomedical applications due to their film-forming ability, controlled bioactivity, biocompatibility, and biodegradability. In recent years, there has been a notable increase in the development of novel polymer blends and composites incorporating various polysaccharides. These biopolymers have attracted considerable attention because of their unique characteristics and broad application potential. Accordingly, the proposed research aligns with ongoing efforts to explore and develop new materials in this field. Polysaccharides are particularly valuable due to their abundance, renewability, and potential to contribute to sustainable processing methods for bioactive and biodegradable materials. This is especially important given the growing concerns over the sustainability of synthetic polymers and the environmental impact of microplastics. This research focuses on the preparation, properties, and applications of polysaccharide-based biocomposites in various physical forms, including gels, films, and 3D porous structures. Recently, ionic liquids and deep eutectic solvents have emerged as promising new solvents for polysaccharides. Often referred to as "green solvents," ionic liquids are notable for their ability to be regenerated and reused, significantly reducing environmental impact. Both ionic liquids and deep eutectic solvents can facilitate the development of innovative materials based on cellulose, chitin, or chitosan for applications in medicine, pharmacy, and cosmetics. Polymer composites play a crucial role in expanding polymer applications. A straightforward approach involves blending polysaccharides with inorganic and/or organic compounds, enabling the creation of materials with tailored properties without compromising the essential characteristics of the original components. Therefore, this project aims to prepare and evaluate the physicochemical properties of new polysaccharide composites enhanced with inorganic and/or organic additives.

1.3. Work plan

1. Purification, modification and characterization of the selected polysaccharides.

2. Preparation of thin films and 3D porous structures from the selected polysaccharides with organic additives using deep eutectic solvents or ionic liquids as solvents.
3. Evaluation of physicochemical properties using advanced techniques such as microscopy, spectroscopy, X-ray diffraction, thermal analysis, tensile tests, swelling behaviour, and surface free energy calculation via contact angle measurements to gain insights into structure, morphology, wettability and surface characteristics.
4. Interpretation of observed changes in the composites' properties based on experimental results.

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

1. L. Yu, K. Dean, L. Li, Polymer blends and composites from renewable resources. Prog. Polym. Sci. 31 (2006) 576–602
2. S. Stolte, M. Matzke, J. Arning, A. Böschen, W.-R. Pitner, U. Welz-Biermann, et al. Effects of different head groups and functionalised side chains on the aquatic toxicity of ionic liquids, Green Chem. 9 (2007) 1170–1179.
3. Y. Duan, A. Freyburger, W. Kunz, C. Zollfrank, Cellulose and chitin composite materials from an ionic liquid and a green co-solvent, Carbohydr. Polym. 192 (2018) 159–165.
4. A. Khan, K.A. Alamry, Recent advances of emerging green chitosan-based biomaterials with potential biomedical applications: A review, Carbohydr. Res. 506 (2021) 108368.
5. M. Kostag, O.A. El Seoud, Sustainable biomaterials based on cellulose, chitin and chitosan composites - A review, Carbohydrate Polymer Technologies and Applications, 2 (2021) 100079.
6. R. Sulthan, A. Reghunadhan, S. Sambhudevan, A new era of chitin synthesis and dissolution using deep eutectic solvents- comparison with ionic liquids, J. Mol. Liq. 380 (2023) 121794

1.5. Required initial knowledge and skills of the PhD candidate

Basic knowledge in polymer chemistry, chemistry, fluent English, commitment to scientific work, permanent self-education, teamwork skills, the ability to interpret and describe experimental results and draw conclusions.

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

Acquiring advanced knowledge in the field of polymer chemistry; practical skills: methodology of obtaining new and multifunctional polymer materials for cosmetics and biomedical applications and their characterisation using modern instrumental analyses; the ability to write scientific publications and presentation of results at international and national conferences; ability to write scientific projects (grant applications); formulate and solve problems related to contemporary technology challenges; prepare for independent scientific work.