Isolation, Characterization, and Applications of Pectic Polysaccharides from Medicinal Plants and Agricultural Waste

Summary

This PhD project aims to explore the multifaceted world of pectic polysaccharides derived from various plant sources. The core objectives are to isolate these biopolymers, compare their physicochemical properties and structures, characterize the formation mechanisms and properties of gels/composite gels (including hydrogels, aerogels, cryogels, oleogels) prepared from them, and finally, evaluate their antioxidant and antibacterial activities. The PhD project will not only contribute significantly to the fundamental understanding of these polysaccharides from diverse sources but also provide valuable insights into their potential for developing advanced functional materials with applications across the food, pharmaceutical, and other biotechnological sectors.

Research field:	Chemistry and biotechnology
Supervisors:	Merike Vaher Piia Jõul
Availability:	This position is available.
Offered by:	School of Science Department of Chemistry and Biotechnology
Application deadline:	Applications are accepted between June 01, 2025 00:00 and June 30, 2025 23:59 (Europe/Zurich)

Description

The research

Beyond conventional sources such as citrus peels and apple pomace, this research will explore agricultural waste (e.g., fruit and vegetable residues, specific plant parts from processing) and potentially medicinal plants (e.g., specific herbs or their by-products known for bioactivity). The selection will prioritize sources with high potential for novel pectic polysaccharides structures or sustainable valorization.

The project will employ and optimize various extraction methods (e.g., acid-hydrolysis, enzymatic extraction, microwave-assisted extraction, ultrasound-assisted extraction) to maximize yield and preserve the integrity of the pectic polysaccharides. This will involve investigating the influence of extraction parameters on the extracted pectic polysaccharides properties.

The isolated pectic polysaccharides will undergo rigorous characterization to understand their fundamental properties: chemical composition, molecular properties, rheological behavior, detailed structural analysis using techniques such as NMR, FTIR, AFM, SEM *etc*.

The research will examine how varying pectic polysaccharides concentration, pH, temperature, and cross-linking agents (such as calcium ions for LM-pectic polysaccharides and specific cations for unique pectic polysaccharides) affect gelation kinetics, strength, elasticity, and water retention in hydrogels; the influence of pectic polysaccharides structure and drying processes on porosity, surface area, mechanical stability, and thermal insulation in aerogels; and the interaction mechanisms between pectic polysaccharides and oils along with their impact on the rheological and textural properties of oleogels.

Evaluation of antioxidant and antibacterial activity focuses on the functional bioactivity of the isolated pectic polysaccharides and their derived gels, assessing their potential for applications where health benefits or preservation are key.

Responsibilities and (foreseen) tasks

- Compile an analytical framework for examining experimental approaches for the identification, separation, and characterization of the extracted compounds
- Map possible case studies about the use of similar materials, experimental approaches used and innovations in the relevant fields
- Contribute to comparative data collection by running experiments, analyzing the data and ensuring a high analytical quality of the results
- Communicate latest results at group discussions, as well as at seminars and conferences

- Publish the obtained results in at least 3 original publications

Applicants should fulfil the following requirements:

- a master’s degree in the field of chemistry, material science or chemical engineering with a specialization in organic chemistry or excellent results in organic chemistry courses
- experience in and knowledge of the different (mineral) resources relevant to and located in Estonia
- a minimum of two years of work experience in a research laboratory
- sufficient knowledge of typical analytical methods used in the field
- a clear interest in the topic of the position
- willingness to teach and supervise bachelor's and master's students
- excellent written and spoken English (minimum C1 level)
- strong and demonstrable writing and analytical skills
- capacity to work both as an independent researcher and as part of a team

The following experience is beneficial:

- working knowledge of statistics and data analysis
- experience in analytical chemistry and chemical analysis in general (composition, etc.)
- compliance to good laboratory practice
- participation at and experience in presenting at scientific conferences
- interest in developing new methods

We offer:

- 4-year PhD position in the leading laboratory dealing with oil shale valorisation and development of the technology of chemical transformationprocesses
- The chance to do high-level research in a field of high national importance
- Possibility to participate in the education and training of a new generation of young scientists
- Opportunities for conference visits, research stays and networking with globally leading universities and research centres

About the department

The department of Chemistry and Biotechnology was created in the School of Science in 2017. The institute merged the former Institute of Chemistry and the Institute of Gene Technology from the Faculty of Mathematics and Natural Sciences and the Institute of Food Science from the Faculty of Chemistry and Materials Technology. Recent scientific discoveries in chemistry, molecular biology and food technology have opened completely new perspectives in fields as medicine, industry, agriculture, and the environment. The work will be conducted at the Division of Chemistry. The main research areas of the division include analytical, computational, industrial, organic, supramolecular, and wood chemistry. The Division of Chemistry is responsible for education in these fields at the bachelor's, master's, and doctoral levels, thus ensuring the ongoing cultivation of proficient specialists in chemistry. In our research and teaching, we put emphasis on the development and implementation of sustainable and green thinking.

Additional information

For further information, please contact merike.vaher@taltech.ee and piia.joul@taltech.ee.

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