Valorization technologies and analytical chemistry of woody biomass and secondary lignocellulosic raw materials

Summary

The overall goal of the project is the development of green fractionation technologies for the extraction, purification and depolymerization of lignin from different kinds of biomass and its further chemical valorization. By harnessing the potential of lignin as renewable resource this project also contributes to the development of various new lignin-based functional materials (carbon fibers, adhesives etc.) that can effectively replace fossil-based counterparts —a goal that aligns with the principles of responsible consumption and production outlined in the United Nations SDG. The project also focuses on the development of reliable analytical methods for the qualitative and quantitative assessment of feedstock, fractionation products and new materials.

Research field:	Chemistry and biotechnology
Supervisors:	Dr. Tiit Lukk Dr. Maria Kulp
Availability:	This position is available.
Offered by:	School of Science Department of Chemistry and Biotechnology
Application deadline:	Applications are accepted between June 01, 2024 00:00 and June 30, 2024 23:59 (Europe/Zurich)

Description

Lignocellulosic biomass is a highly abundant renewable source of three biopolymers: lignin, cellulose and hemicellulose, which can be used for replacing fossil-based resources in manufacturing of chemicals, fuels, and functional materials. Lignin is an attractive raw material that can be converted into several types of high-value-added products, including chemicals, bio-plastics, adhesives and even carbon fibers. For that efficient and sustainable lignocellulose pretreatment technologies are needed to isolate, purify and depolymerize lignin.

Deep eutectic solvents have gained considerable interest due to their excellent capability of solubilizing lignin from biomass and homogeneously react or process lignin. DESs are designer solvents, as they can be combined with different quaternary ammonium salts with diverse HBDs. Therefore, task-specific DESs with a wide range of physico-chemical characteristics can be prepared. DESs can not only depolymerize lignin, but also make lignin more reactive e.g. with furfural, providing a remarkable potential for development of one-pot technology for preparation a lignin-based composite adhesive and achieve the replacement of fossil-based products (phenol and formaldehyde) with renewable bio-based sources (lignin and furfural).

The high purity of DES-lignins makes possible to use them in preparation of carbon fibers as well.

Contemporary analytical chemistry acting at the interplay between composition and structure on one side and properties and functionality of complex materials on the other is able to provide a detailed description of the chemical constitution of complex and often highly heterogeneous objects, which is crucial for evaluating of fractionation processes efficiency and quality of obtained products.

The aims of the project are (1) to develop and apply green methods (organosolv, DES) for lignin isolation from woody biomass and secondary lignocellulosic raw materials, (2) to develop functional materials (thermoplastics, adhesives, carbon fibers etc.) from different lignins (organosolv, DES, Kraft etc.), (3) to develop and apply different analytical methods (HPLC/MS, GC/MS, SEC, capillary electrophoresis, FTIR, NMR), statistical design of experiments and chemometric approaches for processes and products characterization.

Responsibilities and (foreseen) tasks

- Devise strategies for biomass fractionation and lignin purification using deep eutectic solvents and organosolv/catalyst systems;
- Characterization of the efficacy of different organosolv/catalyst systems, suitability of variable deep eutectic solvents and quality of obtained products by analytical methods (classic wet-chemistry and instrumental methods of analysis, HPLC/MS, GC/MS, SEC, capillary electrophoresis, FTIR and NMR spectroscopy combined with chemometric methods);

- Development of the synthetic strategies for lignin-based thermoplastics, adhesives, adsorbents and other functional materials;
- Planning and optimization of experiments using different experimental design approaches (e.g. response surface modelling);
- Contribute to the organization of research and practitioner workshops where project findings are presented.

Applicants should fulfil the following requirements:

- MSc degree in applied or analytical chemistry
- A clear interest in the topic of the position
- Previous experience in material science and analytical chemistry
- Experience in multidimensional statistic analysis
- Excellent English in communication and in writing, team working attitude
- Strong and demonstrable writing and analytical skills
- Capacity to work both as an independent researcher and as part of an international team
- Capacity and willingness to provide assistance in organizational tasks relevant to the project

(The following experience is beneficial:)

- Previous experience in validation of analytical procedures
- Previous experience in quality assurance in chemical/instrumental analysis

- Working knowledge of Solo or other chemometric software
- Experience in chemistry of biopolymers is a plus

We offer:

- 4-year PhD position in one of the largest, most internationalized and leading universities in Estonia
- The chance to do high-level research in the field of renewable raw materials valorization and contemporary analytical chemistry
- Opportunities for conference visits, research stays and networking with globally leading universities and research centers in the field of natural science and sustainable development

About the department

The department of Chemistry and Biotechnology was created in the Faculty of Science in 2017, founding director was Ivar Järving. 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 up completely new perspectives in fields as medicine, industry, agriculture and the environment.

(Additional information)

For further information, please contact Dr. Maria Kulp maria.kulp@taltech.ee and Dr. Tiit Lukk tiit.lukk@taltech.ee or visit https://puidukeemia.ee/tooruhmad/puidupolumeeride-fraktsioneerimine-ja-analuutiline-keemia/ and www.chem-lab.taltech.ee

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