Expanding the sustainability of industrial waste materials and their valorisation by-products

Summary

The overall long-term goal of the project is to change the perspective of the oil shale industry by focusing on the transformation of organic materials present in different waste streams of the industry into valuable chemicals. This will eventually lead to the development of an environmentally friendly chemical industry. To achieve this goal, methods for the sustainable use of by-products from the oil shale valorisation processes need to be either developed or the existing methods need to be optimized for the specific resources available. The objective is to further develop innovative uses for raw materials that create added value and significantly enhance the efficiency of local resource utilization, which aligns with the general green transition strategies. More specifically, the focus of this PhD project is set on the separation and implementation of the by-products formed during the valorisation of organic material from waste rock piles. The project addresses the following research questions: What are the potential streams to be used as sources for valorisation? What are the optimal conditions for the specific resources? What type of products can be obtained and what is their market potential? What are the potential industrial uses for the obtained materials (for example, can they be used in the building industry, etc.)?

Research field:	Chemistry and biotechnology
Supervisors:	Dr. Birgit Mets Dr. Kristiina Kaldas
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

Every year huge amounts of waste materials containing some amounts of versatile organic compounds are produced in Estonia. The main source for potentially valuable waste streams in Estonia is the oil shale industry which utilizes the pyrolysis process. Currently, the valorisation potential of the produced waste streams has not been exploited to the fullest. The discarded organic matter can be found as kukersite in waste rock piles, graptolitic argillite, and even agricultural waste. This project focuses on developing solutions of chemical technology that would allow converting various organic-rich materials, particularly kukersite that is found in large quantities in the waste of oil shale industry, piled-up in Ida-Virumaa over several decades, into secondary raw materials for the production of materials such as polymer blends, new generation polyols, adhesives, or resins for the construction industry as well as platform chemicals. In addition to traditional chemical modification methods, other, previously not applied transformation methods of the derivatized kukersite kerogen (like for example the use of mechanochemistry) can lead to entirely new results. Although the focus is on Estonian organic-containing mineral resources, as a further step, the method will be extended to other raw materials.

The goal of this PhD project is to examine the potential of the by-products formed during the valorisation of waste oil shale. Specifically, the project should focus on the solid, liquid, and gaseous streams formed during the process and find ways on how to utilize them. As an example, the organic-rich solid residue could potentially exhibit plant growth promoting properties, whereas the separation of the mineral part could lead to products suitable for the composition of building materials. Additionally, the properties of the main valorisation product blends will be investigated to determine their usability in plastics, with the novelty lying in their use as blends, without prior purification.

The thesis should address the following questions:

1) What are the properties and amounts of the main by-products and streams produced during the valorisation of waste oil shale?

2) What possible industrial uses can the produced materials and compounds have?

3) How can the components of interest or useful parts of the streams be separated, and do they need further purification?

4) Can dicarboxylic acid blends be directly used to enhance the properties of the produced plastic or other polymeric blends?

5) Do the by-product materials need further modifications or transformations to increase their value and usability?

Responsibilities and (foreseen) tasks

- Compile an analytical framework for examining experimental approaches for the identification, separation, and characterization of the produced material streams
- 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

The candidate should submit a research plan for the topic, including the overall research and data collection strategy and a clear view of how to best approach the topic. The candidate can expand on the listed research questions and tasks and must propose theoretical approaches to be used. To be included with the research plan are the CV with details about the education, work experience and skills of the candidate, and at least two professional references from respected researchers of the university.

We offer:

- 4-year PhD position in the leading laboratory dealing with oil shale valorisation and development of the technology of chemical transformation processes
- 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 up 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.

The research and teaching facilities at the Division of Chemistry are furnished with modern equipment, supporting high-level research and education. A total of 10 research groups operates within our division, with approximately 80 academic staff members, including 4 professors and 25 doctoral students. Our researchers are engaged in international networks and cooperations, making their research worldwide visible.

Additional information

For further information, please contact Senior Researcher Birgit Mets birgit.mets@taltech.ee and Senior Researcher Kristiina Kaldas kristiina.kaldas@taltech.ee or visit https://taltech.ee/en/department-chemistry-biotechnology/division-of-of-chemistry

To get more information or to apply online, visit https://taltech.glowbase.com/positions/763 or scan the the code on the left with your smartphone.