Conversion of bio-oils and oil shale industry by-products into porous carbon materials for hydrogen storage

Summary

This topic aims to contribute to the development of innovative hydrogen storage materials as sustainable energy sources to help achieve climate neutrality in both the energy and transport sectors. The project uses renewable natural resources (biomass) and solid mineral waste as raw materials to develop a sorbent material for hydrogen storage.

Research field:	Chemical, materials and energy technology
Supervisors:	Prof. Dr. Alar Konist Dr. Kadriann Tamm
Availability:	This position is available.
Offered by:	School of Engineering Department of Energy Technology
Application deadline:	Applications are accepted between June 01, 2024 00:00 and June 30, 2024 23:59 (Europe/Zurich)

Description

Progress in knowledge and values has led humanity to realize the unsustainability of the current model of economy, which is largely based on the consumption of resources and energy. This consumption is directly related to the higher standard of living; however, this well-being is sustainable only through decarbonizing energy systems. It means applying CO_2 capture and utilization, increasing biomass, wind and solar power use, and hydrogen (H_2) production. While there are a number of options for decarbonization, H_2 as an energy carrier (fuel) “offers a versatile, clean, and flexible energy vector for this transition”. H_2 could be one of the cleanest energies with potential to have zero carbon emission. Therefore, H_2 has an important role in future transportation, energy, and industry sectors. To consider H_2 as fuel for balancing the energy grid, there must be production and storage facilities. While green H_2 production and fuel cell technologies are technically ready, there are still obstacles hindering its widespread use.

Promising attempts have been made to solve the problem of storing H_2 in carbon materials due to their high volumetric and gravimetric capacity, and good H_2 storage performance.

A cost-effective approach are zeolites which could be synthesized from waste sources such as coal fly ash or oil shale ash. The obtained fly ash derived zeolite has an estimated cost of one-fifth of that of existing commercial zeolites and could be effectively used as hard template material for obtaining microporous carbon with the surface area of 1112 m^2/g, and H_2 uptake capacity of 1.2 wt% (at 77 K and 1 bar).

The project will extend the knowledge gained from the PSG project “Effects of activation conditions on the preparation of porous carbon from oil shale” (PSG266) by developing a method for preparing H_2 storage material (adsorbent) using materials and methods studied in the PSG project.

In principle, the project will study the production of a suitable template material (either semi-coke or oil shale ash) with excellent properties for H_2 storage.

For the analytical research equipment available in the laboratories of the Department of Energy Technology will be used. I.e:

- Quantachrome Autosorb Anygas analyser for determination of surface area and pore size. Physisorb ports for micro- and mesopores and one chemisorb port;
- NETZSCH Simultaneous Thermal Analyzer STA 449 F3 Jupiter® (TGA/DSC) coupled with Quadrupole MS. Water vapor and high speed furnace (1000 K/min) and other apparatus (https://www.ttu.ee/instituut/energiatehnoloogia-instituut/teenused-22/seadmed-21/).

Responsibilities and (foreseen) tasks

- Prepare a research plan with the help of the supervisor and carry out research according to the plan.
- Conduct necessary laboratory experiments.

- The PhD student will work closely with collaborators from TalTech and abroad (e.g. USA) and will be expected to participate in relevant national and international conferences, and develop journal papers within the research field.

Applicants should fulfil the following requirements:

- A master's degree in thermal, chemical or mechanical engineering
- Good speaking and writing English.
- a clear interest in the topic of the position
- 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:)

- Knowing SimaPro
- Practical experience with TGA analysis
- Previous participation in research projects

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