NEXTGEN roadfuels

Converting biogenic urban liquid fuels for road transport by means of Hydrothermal Liquefaction (HTL)

Newsletter

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1. Collaboration agreement with Norwegian University of Science and Technology

To strengthen the testing of the NextGenRoadFuel biocrude oil the consortium has made an agreement with Norwegian University of Science and Technology (NTNU). This collaboration will make it possible to perform mere comprehensive testing and analysis, hence make it possible for the project to deliver a better result. Overall, the testing and analysis will make the finished biocrude more relevant for the end users and take into consideration the specifications requested by the users.

Figure 1: Fast pyrolysis in the bioliq® plant at KIT University
Credit: Emma Fromant

2. Consortium Meeting at KIT

The latest consortium meeting was held from 17th -18th November 2021 at the Karlsruhe Institute of Technology, and for the first time in nearly two years some of the consortium were able to meet in person. The meeting was held as a hybrid format to allow attendance for all partners, even those unable to travel due to COVID-19 restrictions.

The two day meeting was very successful with each work-package actively participating in group discussions and project update presentations. The next consortium meeting is due to be held in early summer 2022, hosted by CPERI in Greece.

Figure 2: Consortium meeting at KIT (November 2021)
Credit: Emma Fromant

3. Steeper Energy is expanding operations in Denmark based on its hydrofaction® technology to create advanced biofuels for heavy and long-haul transport.

Since 2011 Steeper has been present in Denmark collaborating with Aalborg University to set up a pilot plant and to conduct various research projects in the field of biofuels from lignocellulosic biomass.
As such the Danish government has seen the potential for Steeper Energy's new technology, that utilises bio waste and biomass to create green fuels, as a key area of investment in order to reduce CO2 and achieve the government's ambitious carbon reduction goals.

Figure 3: The workings of the bioliq® plant at KIT University
Credit: Emma Fromant

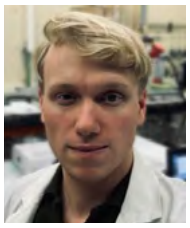
4. Meet the PhD research students

Many of the interesting and valuable results produced so far should be attributed to the hard working research students based at Aalborg University, Karlsruhe Institute of Technology (KIT) and Technical University of Munich (TUM). As part of this Newsletter we are given the opportunity to hear from our students.

Simon Krebs, TUM
Simon Krebs was born in Wasserburg am Inn, Germany. He completed his Bachelor and Master studies in Chemistry at TUM, and his Masters thesis focused on isobutane/butene alkylation.

Figure 4. Tour of KITs southern campus

Simon's current study focus was inspired by the increasing energy and fuel demand worldwide, and the need for alternative resources.
The NextGenRoadFuel project addresses this topic as it focuses on the use and upgrading of alternative resources, such as biomass or sewage sludge, to be used as a fuel.
Simon's research includes the electrochemical upgrading of bio crude, which has produced promising results of the possibility to perform upgrading by using electric energy, which can be generated by a renewable energy source.



Joscha Zimmermann, KIT
Joscha completed his Bachelor in "Chemical Technology" at the University of Applied Science in Mannheim and his Master in "Bio-based Products and Bioenergy" at the University of Hohenheim.
Whilst writing Masters Thesis on the application of carbon material derived by hydrothermal carbonization in a direct carbon fuel cell, he became interested in hydrothermal processes.
Since 2019, he has been working as a PhD Student for the Institute of Catalysis Research and Technology at KIT on the optimization of the hydrothermal liquefaction process chain from waste biomass to fuel. This research includes the reaction behaviour of the heteroatoms, especially the interaction and removal of nitrogen compounds during the process and the challenges to unravel the complexity of the received biocrude.
The first results on the influence of the biogenic composition of feedstock and the potential to remove nitrogen in a pre-treatment, are published in Zimmermann et al 2021: "Sequential Hydrothermal Processing of Sewage Sludge to Produce Low Nitrogen Biocrude".
Joscha's future research interests include the application of advanced analytical tools on HTL and upgrading products, and the chemical challenges associated with establishing a sustainable society.

Ali Sayegh (KIT)
Ali has a diploma in civil engineering and a Master in water science and engineering.
Since 2019, he has been working with Engler-Bunte-Institut, Water Chemistry and Water Technology at KIT under the guidance of Prof. Horn/Dr. Saravia.
Having faced the problem of water quality and shortage during his childhood, Ali became interested in researching solutions for wastewater treatment and drinking water production.
The importance of the NGRF project in this field, is that it offers a solution to the treatment of the complicated produced liquid byproduct.
Characterizing the components of this liquid has been a challenge for Ali, as well as deciding and executing the treatment procedure, but with good planning and patience, he was able to complete the task.
Ali now has a complete set of results, and has begun writing and publishing them. Although the PhD project will end within the next year Ali's interest in research has just begun.

Komeil Kohansal (AAU)
Komeil graduated with a Bachelor degree in applied chemistry in 2016, and Master degree in 2019 from Tehran University, after which he started a PhD at AAU in the department of energy technology.
His Master's thesis focused on hydrothermal liquefaction and he was interested in researching crude oil refinery processes, both components of the NGRF project. Komeil believes that the capability of Hydrothermal liquefaction technology in fuel production and its contribution to sustainable waste disposal are the two most important aspects of the research.
NGRF has gathered lots of experts in different fields, from waste treatment to fuel producers.
Together with his supervisor (Thomas Helmer Pedersen), Komeil has published two scientific papers (different aspects of recirculation of aqueous phase), and is currently working on another one.
Moreover, with a collaboration with AAU BUILD, he submitted a manuscript regarding the destructive effect of HTL on the microplastic content of sewage sludge. Komeil has also presented results in three different international conferences, including EUBCE 2020, TCS 2020, AIChe 2020.
His current research interests are in HTL bio-crude upgrading, fuel properties, and the possibility of production of a biodiesel blendstock through the technology.

5. Published papers

After three years of research, NGRF now has the main bulk of results that are busily being written up and published. This Newsletter introduces the three most recent publications.

Techno-economic evaluation of carbon capture via physical absorption from HTL gas phase derived from woody biomass and sewage sludge

Written by E.M.Lozano, S.B.Petersen, M.M.Paulsen, L.A.Rosendahl, and T.H.Pedersen, at the Department of Energy Technology, Aalborg University. This paper is published in Energy Conversion and Management: X, Volume 11, September 2021, and the full version can be found here: Science Direct.

Abstract: Due to its capability to produce negative CO2 emissions, bioenergy in combination with carbon capture and storage (BECCS) has been identified as a key technology to limit global warming and to support the energy transition in pursue of the climate targets of this century. Among different bioenergy applications, advanced liquid biofuels produced through the hydrothermal liquefaction (HTL) of waste biomass have gained interest as promising drop-in alternatives to fossil fuels.
However, there is lack of studies in literature that evaluate the potential of HTL as negative emission technology in the context of BECCS and present detailed process design of such an implementation for different types of biomass. In this paper, we perform carbon capture modeling based on state-of-art experimental data on HTL of waste lignocellulosic and urban biomasses by means of physical absorption via the Selexol™ process.
The process model is utilized for developing a techno-economic analysis that highlights key parameters to optimize CO2 capture cost efficiency.
The results indicate that the purity of the CO2 product fulfils the requirements for geological storage in all cases studied, and is on-spec for pipeline transportation when the composition of C2+ hydrocarbons and H2S in the HTL gas are kept below 4 and 1 mol % respectively, or by the implementation of two absorption steps.
For the standard process evaluated, the estimated cost of the captured CO2 is between 40 and 53 EUR/tonne, which is in the range of the carbon price expected within this decade in the EU emission trading system, given the announced cap reductions until 2030 and the targets set by the European Green Deal.

Bioenergy in combination with carbon capture and storage (BECCS) is a key technology to limit global warming

Treatment of hydrothermal liquefaction wastewater with ultrafiltration and air stripping for oil and particle removal and ammonia recovery

Written by Ali Sayegha, Nikhil Shylaja, Prakashc Thomas, Helmer Pedersenb, Harald Hornac, and Florencia Saravia, at Karlsruhe Institute of Technology and Aalborg University. This paper is published in Journal of Water Process Engineering, Volume 44, December 2021, and the full version can be found here: Science Direct.

Abstract: This study aims to evaluate the application of ultrafiltration technology for the separation of particles and oil droplets and the recovery of ammonia from hydrothermal liquefaction (HTL) wastewater.
Real HTL wastewater from the hydrothermal liquefaction of municipal sewage sludge was used in this study. Experiments were carried out using a submerged polyethersulfone ultrafiltration membrane with molecular weight cutoff of 100 kDa in combination with air stripping and addition to acid and base traps for recovery of volatiles.
Results showed, that the best operation mode of ultrafiltration is with backwash cycles of the permeate, maintaining a flux lower than the critical flux of 6 L/h·m2.
The setup led to fast stripping of ammonia, which was successfully recovered by 88% in the acid trap. This application can be considered an adequate first stage treatment of the HTL wastewater.
The importance of this work is that it proves that membrane technology can be successful in treating complex real HTL wastewater, and is not only limited for applications using model solutions.

Membrane technology can be successful in treating complex real HTL wastewater

Bio-Crude Production Improvement during Hydrothermal Liquefaction of Biopulp by Simultaneous Application of Alkali Catalysts and Aqueous Phase Recirculation

Written by Komeil Kohansal, Kamaldeep Sharma, Saqib Sohail Toor, Eliana Lozano Sanchez, Joscha Zimmermann, Lasse Aistrup Rosendahl and Thomas Helmer Pedersen, at Karlsruhe Institute of Technology, and Aalborg University.

This paper is published in Energies 2021, 14(15), and the full version can be found here: MDPI.

Abstract: This study focuses on the valorization of the organic fraction of municipal solid waste (biopulp) by hydrothermal liquefaction.
Thereby, homogeneous alkali catalysts (KOH, NaOH, K2CO3 , and Na2CO3) and a residual aqueous phase recirculation methodology were mutually employed to enhance the bio-crude yield and energy efficiency of a sub-critical hydrothermal conversion (350 °C, 15–20 Mpa, 15 min). Interestingly, single recirculation of the concentrated aqueous phase positively increased the bio-crude yield in all cases, while the higher heating value (HHV) of the biocrudes slightly dropped.
Compared to the non-catalytic experiment, K2CO3 and Na2CO3 effectively increased the bio-crude yield by 14 and 7.3%, respectively.
However, KOH and NaOH showed a negative variation in the bio-crude yield. The highest bio-crude yield (37.5 wt.%) and energy recovery (ER) (59.4%) were achieved when K2CO3 and concentrated aqueous phase recirculation were simultaneously applied to the process. The inorganics distribution results obtained by ICP reveal the tendency of the alkali elements to settle into the aqueous phase, which, if recovered, can potentially boost the circularity of the HTL process.
Therefore, wise selection of the alkali catalyst along with aqueous phase recirculation assists hydrothermal liquefaction in green biofuel production and environmentally friendly valorization of biopulp.

Figure 5. Biofuel production experimental equipment at KIT. Credit: Emma Fromant

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