

18<sup>th</sup> September, 2020 | 13:30 - 14:45

Joscha Zimmermann, KIT, Institute of Catalysis Research and Technology

## Thermochemical pre-treatments for the hydrothermal liquefaction of sewage sludge

Joscha Zimmermann, Dr. Klaus Raffelt, Nicolaus Dahmen  
 Karlsruhe Institute of Catalysis Research and Technology  
 Hermann-von-Helmholtz-Platz 1  
 76344 Eggenstein-Leopoldshafen  
 E-Mail: [joscha.zimmermann@kit.edu](mailto:joscha.zimmermann@kit.edu)

Hydrothermal liquefaction (HTL) is a thermochemical process for converting directly wet biomass and organic residues into bio-crude. This product can be applied as a drop-in transportation fuel or substitute petroleum in refineries. Advantages of the process are high conversion rates, the catalytic effect of the reaction medium water and, consequently, the previously mentioned ability to utilize a wet feedstock like sewage sludge. Nevertheless, the production of biofuels by HTL of sewage sludge involves several problems, especially in regard to the inorganic components and the formation of heteroatomic compounds. Sewage sludge has a relatively high content of inorganics, mostly alkali and alkaline earth metallic species, which were used upstream in the wastewater treatment process. This high ash content in the feedstock is reflected in the bio-crude yield and quality and challenges the catalytic upgrading to fuels e.g. by a decrease in catalyst activity due to poisoning and depositions. Additionally, sewage sludge is a biogenic material rich in proteins and contains, in particular, high amounts of nitrogen and sulphur. These heteroatoms can reduce the heating value, lead to undesirable emissions and thus increase the costs for downstream processing. In this study, we investigate the influence of different pre-treatment methods prior to sewage sludge conversion. Different leaching-agents and temperatures are applied to transfer inorganics and organic nitrogen into the liquid supernatant. In a next step, the resulting solids will be dewatered and converted into bio-crude

by HTL. Research work focuses on how the sludge changes in its physical-chemical composition by the pre-treatment, the impact on the HTL product yields as well as on the bio-crude quality. Therefore, the bio-crude is being separated into different fractions to determine the elemental composition and, consequently, their species. The overall goal of this work is to develop an efficient pre-treatment method for HTL of sludge. It is expected that an acid pre-treatment at ambient temperature remove inorganic constituents from the sewage sludge matrix and with rising temperature proteins start to hydrolyse and deamination reactions occur. The treatment will lower the nitrogen, but also the carbon content in the sludge the subsequent HTL bio-crudes will have a higher quality. Additionally the carbon recovery is investigated and correlated with the bio-crude.

This subject is embedded in the Next-GenRoadFuels project and has received funding from the European Union's 2020 Research and Innovation Programme under Grant Agreement No 818413



Institute of Catalysis Research and Technology (IKFT)

## Influence of thermochemical pretreatments on hydrothermal liquefaction (HTL) of sewage sludge

J. Zimmermann, K. Raffelt, N. Dahmen

### Challenge

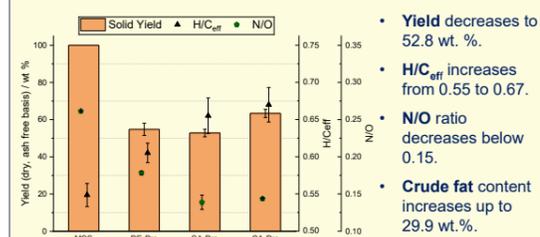
- EU – project: **NextGenRoadFuels - Sustainable drop in fuels from low value urban feedstock**
- Mixed sewage sludge (MSS) contains proteins which result in high content of nitrogen containing compounds in HTL-biocrude.
- Consequently more hydrogen is needed in upgrading

### Objective

- Integrate a process upstream HTL to improve biocrude quality and lower nitrogen content
- Stage 1: Subcritical hydrothermal extraction with different agents
- Stage 2: Hydrothermal liquefaction
- Evaluating quality with H/C<sub>eff</sub> Ratio  $H/C_{eff} = \frac{H - 2O - 3N - 2S}{C}$

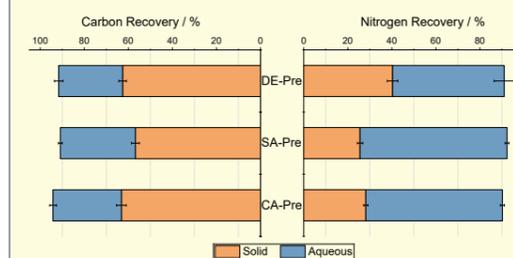


### Pre-treatment step (hydrothermal extraction)



On dry, ash free basis, in wt. %	MSS	DE	SA	CA
Crude fat in solid phase	21.7	24.4	29.9	28.6
Nitrogen in solid phase	7.1	4.7	3.4	3.6

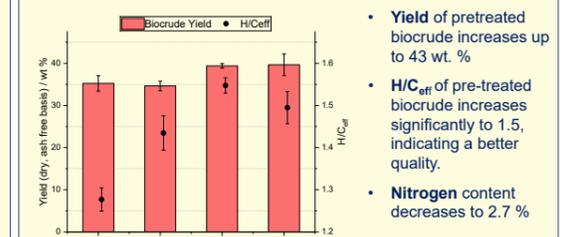
- **Yield** decreases to 52.8 wt. %.
- **H/C<sub>eff</sub>** increases from 0.55 to 0.67.
- **N/O** ratio decreases below 0.15.
- **Crude fat** content increases up to 29.9 wt. %.



### Conclusion

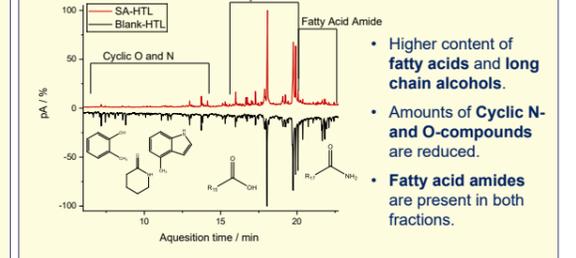
- Effective de-nitrogenation is associated with carbon loss.
- Pre-treatment with SA results in highest quality oil, but also highest carbon loss.
- Quality of Biocrude can be improved significantly, as nitrogen compounds in pre-treated biocrude are primarily fatty acid amides.

### HTL step of solid residue



In wt. %	MSS	DE	SA	CA
Nitrogen in biocrude	5.0	3.8	2.8	2.7

- **Yield** of pretreated biocrude increases up to 43 wt. %
- **H/C<sub>eff</sub>** of pre-treated biocrude increases significantly to 1.5, indicating a better quality.
- **Nitrogen** content decreases to 2.7 %



### Outlook

- Quantification of compounds representing molecular class.
  - Fatty acids, fatty acid amides, lactams, indoles and phenols.
- Optimisation of pre-treatment conditions.
  - Temperature and acid concentration.

### Acknowledgment



This project has received funding from the European Union's 2020 Research and Innovation Programme under Grant Agreement No 818413

KIT – University of the State of Baden-Wuerttemberg and National Research Center of the Helmholtz Association

[www.kit.edu](http://www.kit.edu)