Study on the catalytic heterogeneous direct liquefaction of bovine serum albumine under subcritical water conditions: The case of ammonium

M. Brandenberger [a*], P. Edinger [a], M. Trösch [a], C. Ludwig [a,b], F. Vogel [a]

a: PSI – *Laboratory for Energy and Materials Cycles* , *martin.brandenberger@psi.ch, http://cpe.web.psi.ch

b: EPFL – *Ecole Polytechnique Fédérale de Lausanne, ENAC-ISTE*

Motivation

The **production of biofuels** from biomass requires large amounts of **nutrients**, usually provided to the plants in the form of high quality fertilizer.

Sustainable production of biomass requires the **recover** and **reuse** of nutrients such as **nitrogen, sulphur and phosphorus** contained in the biomass.

PSI's **catalytic hydrothermal process (see figure 3)** consist of an intermediary **salt separation step**, where nutrients, in the form of salts are separated through **gravitational precipitation** from the organic phase.

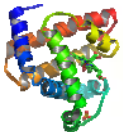
However a potential efficient salt recovery is only achieved if the organically bounded nutrients are previously released from the biomass during the **liquefaction of the biomass** in PSI's catalytic hydrothermal process **preheating step**.

Objective

Study **the first step** in PSI' catalytic hydrothermal process:

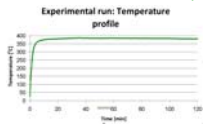
- **Optimize liquefaction** of biomass, with a special focus on proteinaceous biomass which contains large amounts of nitrogen.
- Recover the nitrogen as **ammonium**.
- Find a **suitable catalyst** which improves the **release** of nitrogen from proteinaceous biomass.
- Avoid **tar** and **coke** formation

Method



A 10 wt % **aqueous Bovine Serum Albumine** (BSA, protein composed of 607 amino acids) solution is filled into a 5 ml mini-batch reactor, either in presence or absence of a catalyst.

Liquefaction



Biomass **liquefaction** takes place at **370 °C** and RT between **1 – 120 min.** Standard condtions are 370 °C and RT = 9 min.

Liquefied BSA

Photometric measurement of NH^+_4-N in the product solution

Photometer: Nanocolor 300 D

Results

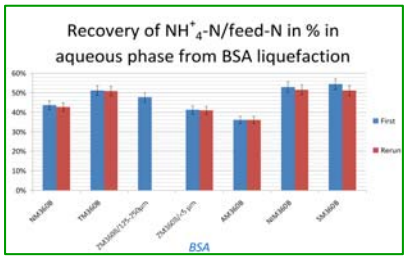


Fig. 1: Ammonium recovery at 370 °C and RT of 9 min with and without catalyst.

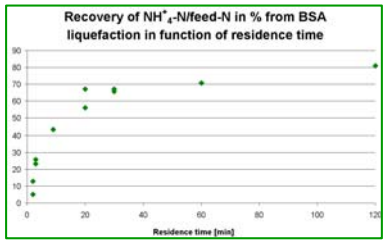


Fig. 2: Ammonium recovery at 370 °C and RT from 1 - 120 min.

PSI's Continuous Test Rig

- Continuous feed of **1 kg/h**
- Concentrations up to **20 wt %** organic material
- Operated almost fully by **remote** control
- The rig consists of three sections:
  - **Preheating**
  - **Salt separation**
  - **Fixed-bed catalytic reactor**
- Pressure max. **35 MPa**

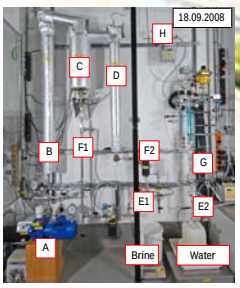


Fig. 3: KONTI 2 – Continuously operated laboratory plant

Conclusion and Outlook

- No catalyst up to now showed significantly better performance after 9 min. residence time than other catalysts or runs done in the absence of catalyst.
- However catalysts made or doped with TiO_2 show slightly better performance than others (run TM360B and run SM360B).
- After two hours residence time, ammonium recovery reaches ~ 80 % NH^+_4-N/feed-N in the absence of catalyst.
- Future catalysts hopefully can speed up nitrogen splitt off to ammonium for shorter residence times, i.e. residence times around 9 min. wich are typical operating conditions for PSI catalytic hydrothermal process.
- Potential bottlenecks, such as chemical equilibrium of nitrogen splitt off and reactant limitation need to be indentified as well as parameters influencing the ammonium recovery.
- Variation of solution pH should give further insights into nitrogen splitt off and its chemistry.

Project partner: Velux-Stiftung