DEPARTMENT OF ENERGY TECHNOLOGY
AALBORG UNIVERSITY

PhD - Public Defence

Title:	Valorization of Waste Fractions through HydroThermal Liquefaction - Conversion of Plastics, Lignocellulosic Materials and Organic Residues into Biocrude and Recovery of Valuable Products
Location:	Online
Time:	Tuesday August 4th at 14.00
PhD defendant:	Federica Conti
Supervisor:	Professor Lasse Rosendahl
Moderator:	Associate Professor Vincenzo Liso
Opponents:	Associate Professor Jens Bo Holm-Nielsen, Dept. of Energy Technology, Aalborg University (Chairman) Professor David Chiaramonti, University of Florence, Italy Associate Professor Professor Brajendra Kumar Sharma, University of Illinois Urbana-Champaign, USA

The defence will be in English - all are welcome

Abstract:

The increasingly visible effects of climate change demand for a larger use of renewable fuels, especially in the transportation sector, in order to reduce GHG emissions and to move forward against fossil fuels dependence. Hydrothermal liquefaction (HTL) is a prospective technology, capable of producing renewable advanced biofuels via thermochemical conversion of the feedstock into biocrude and its consequent upgrading. The peculiarity of HTL is to be able to process a large variety of feedstock regardless from their chemical composition, including wet biomasses, and therefore allowing even the treatment of inhomogeneous wastes.
The present work investigated the HTL of three highly diverse waste fractions with the common aim of valorizing the organic fraction by producing biocrude and, at the same time, investigating the potential recovery of valuable by-products for an improved circular economy.

In the first study, HTL was proposed to process unrecyclable mixed fractions of plastics: to investigate its potentials, nine high-density polymers were individually processed under supercritical water conditions. In most cases, the liquefaction of the plastics resulted in high yields of synthetic crude oils; in particular, PC almost fully converted into biocrude (99.8%), and very high biocrude yields (ca. 80%) were obtained from SB and PPO conversion. From the qualitative characterization, the biocrudes result suitable for fuels and chemicals applications. Furthermore, biocrudes derived from polymers with an aromatic structure may also be used for BTX production, as they contain aromatic compounds. Moreover, monomers were identified in the products after liquefaction of PC, SB, PLA, PBT, and PET; as a result, monomeric compounds may be reclaimed for the production of new plastics. For example, although PET and PBT liquefaction did not produce any biocrude, their conversion resulted in the precipitation of the monomeric compound TPA. From the results of this work, HTL is found being highly prospective for chemical recycling of high-density polymers.

In the second study, HTL was proposed to convert willow used for a particular application: the lignocellulosic biomass was grown on fields irrigated with wastewater for absorbance of nutrients and metals from the waste stream. The supercritical liquefaction of the willow produced high yields (40%) of biocrude oil, a mixture of ketones and phenols, that could be upgraded for the production of fuels. Around 60% of the biocrude was in fact found being made of compounds whose boiling point is in the same range as gasoline, jet fuel, and diesel. The quality of the biocrude was not affected by the presence of the inorganics in the biomass, as most of the investigated inorganics (e.g. Ca, P, Mg, Fe) were primarily recovered in the solids after HTL processing. Potassium and sodium showed a different behavior being, instead, primarily dissolved in the aqueous phase. The concentration of the inorganics in the solids result favorable to both separate undesired heavy metals and recover nutrients for reutilization as fertilizers.

In the third study, HTL was proposed as treatment for the disposal and simultaneous valorization of animal and human organic residues. Swine manure, cow manure, fish sludge, and sewage sludge were thus processed at both sub- and supercritical conditions, in presence and in absence of K_2CO_3 catalyst. The organic fraction of these wastes was substantially valorized through HTL: up to two thirds of the feedstock introduced in the reactor was converted into biocrude (59% for fish sludge, 46% for sewage sludge, and 41% for the manures at the most favorable process conditions). Though higher yields were obtained when operating at lower temperature (350 °C), the quality of the biocrude was enhanced by the use of supercritical conditions (400 °C), especially for the manure-derived biocrudes, for which more severe conditions resulted in a higher deoxygenation extent. Likewise, the addition of K_2CO_3 catalyst allowed reducing the final oxygen content in the biocrudes, with a stronger effect on the biocrudes derived from the manures. Similarly as for the processing of woody biomass, most of the inorganics (Al, Ca, Cd, Cr, Cu, Fe, Mg, Mn, Ni, P, Pb, Zn) were primarily recovered (>70%) in the HTL solids after hydrothermal processing. Since these waste fractions have high inorganic content (around 10% in the manures and >20% in the sludges) and are a particularly abundant source of phosphorus, HTL holds great potential for the recovery of a large volume of phosphorus.

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The outcomes of the present PhD work confirm the high flexibility of the HTL process towards the processing of highly inhomogeneous and diverse waste streams.
The results of the experimental activities conducted within this work are also intended for utilization in support of the development and upscaling of the HTL technology.