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Hydrothermal liquefaction of high ash containing sewage sludge at sub and supercritical conditions

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Abstract

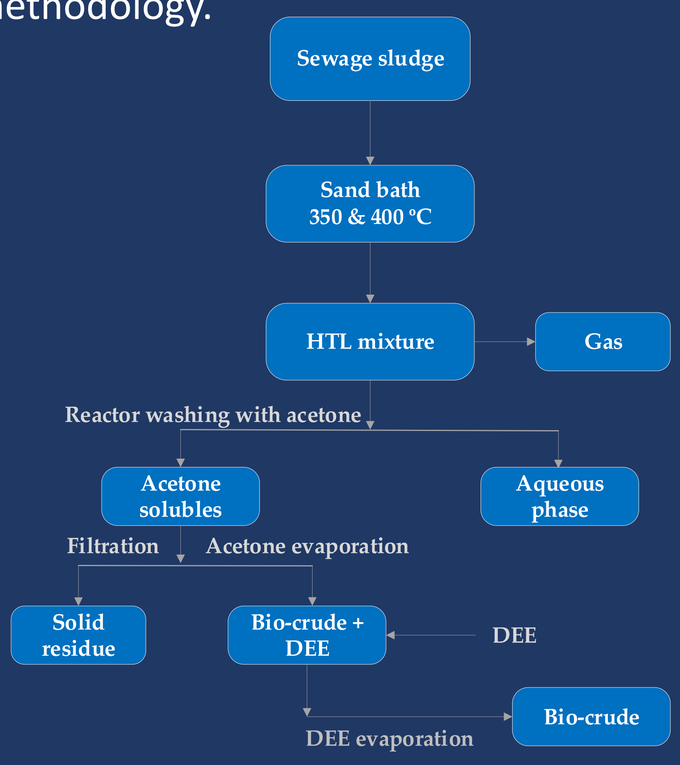
With the rapid growth in population and urbanization, sustainable disposal of sewage sludge has become a prominent problem worldwide. Therefore, an adequate treatment is required to reduce the environmental impacts created from traditional methods such as incineration, landfill, etc. In this context, sewage sludge has been liquefied hydrothermally under sub-supercritical conditions, with and without catalyst (K_2CO_3) in micro-batch reactors.

Objectives

- To convert sewage sludge into the high quality bio-crude.
- To investigate the effect of temperature and catalyst on product distribution at sub and supercritical conditions.

Methodology

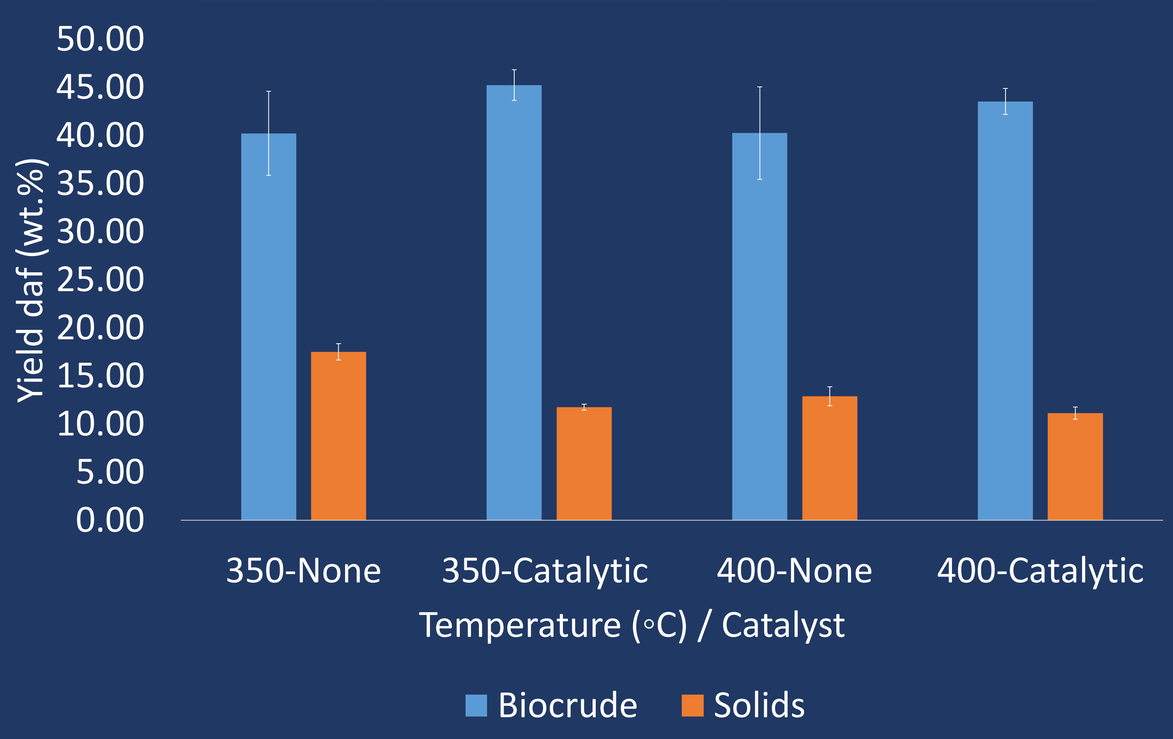
A secondary Sewage sludge sample was collected from Aalborg East Wastewater Treatment Plant, Forsyning (Renseanlaeg Ost), Aalborg East, Denmark. Later on, the liquifaction experiments were performed at sub & supercritical conditions by adopting the following methodology.



Proximate and ultimate analysis of sewage sludge (daf wt.%)				
Moisture	Ash	Protein	Fat	Carbohydrate
73.39	40.63	43.16	7.79	48.16
C	H	N	O	HHV (MJ/kg)
50.95	7.36	6.91	34.78	22.15

Results

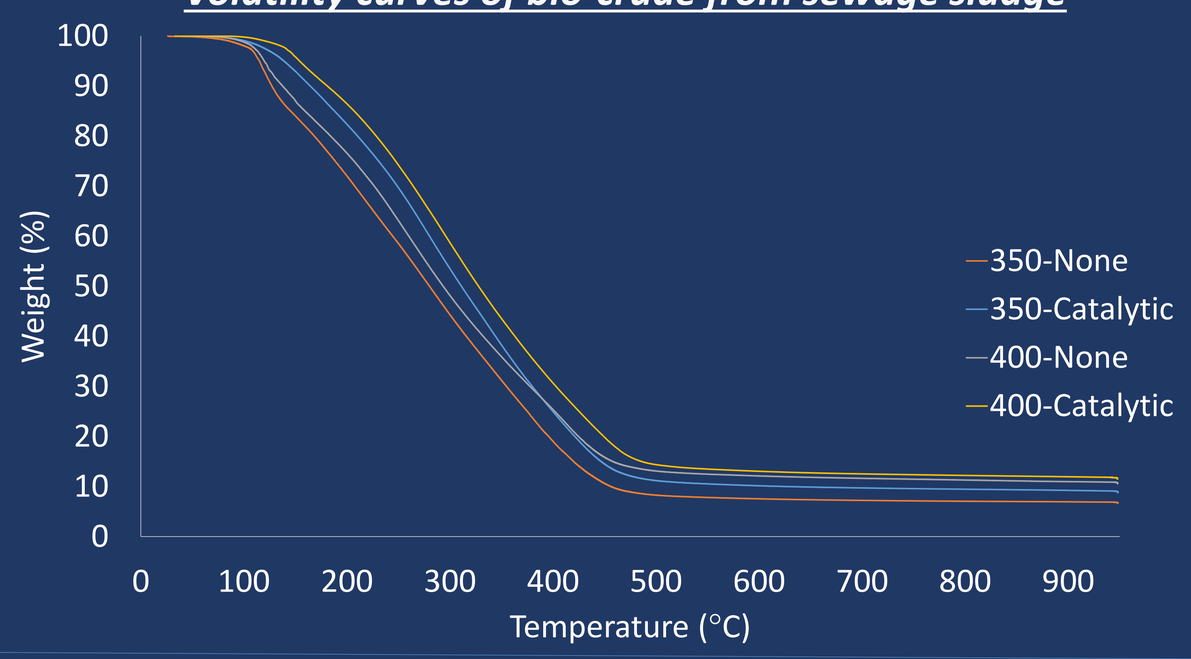
Bio-crude yields at sub and supercritical conditions



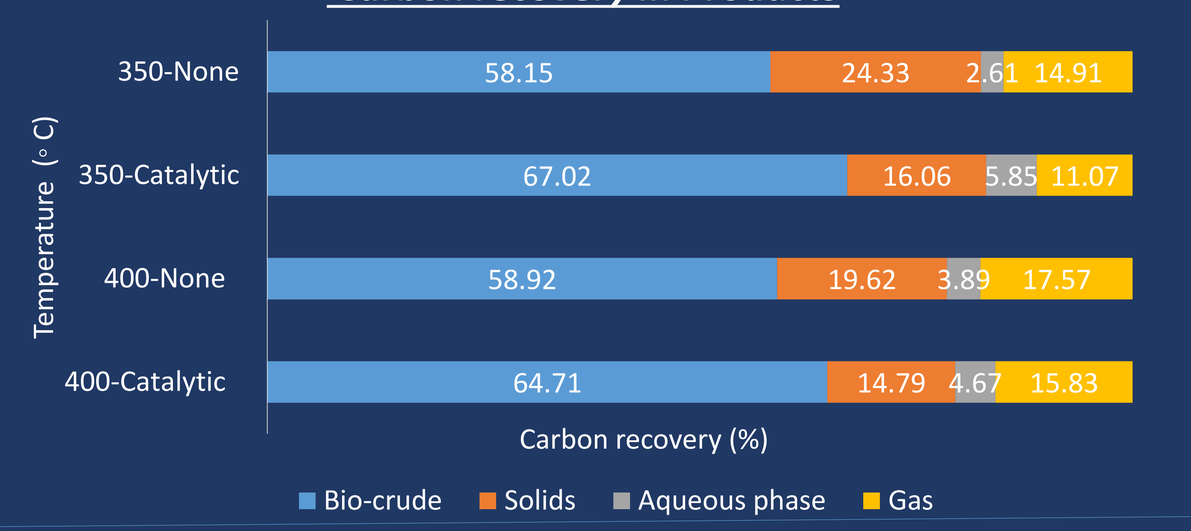
Bio-crude Quality from sewage sludge

Samples	C (%)	H(%)	N(%)	O(%)	HHV (MJ/kg)	ER (%)
Sew. sludge	30.25	4.37	4.10	20.67	13.17	----
350-None	73.68	10.09	5.71	10.52	35.30	63.98
350-Catalytic	75.51	10.56	4.69	9.24	36.60	74.60
400-None	74.60	10.33	5.20	9.88	35.95	65.21
400-Catalytic	75.75	10.22	3.77	10.26	36.21	71.04

Volatility curves of bio-crude from sewage sludge



Carbon recovery in Products



Conclusion

- *The temperature had a negligible influence on bio-crude yield and quality, whereas catalyst (K_2CO_3) slightly improved both the yield and quality.*
- *The overall, 58-67% of the carbon went into the bio-crude at both sub and supercritical conditions.*
- *The bio-crude at supercritical conditions contained lower nitrogen, which indicates that higher temperature is favorable for lower N-content in bio-crude.*
- *The supercritical aqueous phase contained high TOCs as compared to subcritical. The overall TOCs of the aqueous phases in the range of 23 to 49 g/l, which could be used as a recirculation solvent.*
- *Based on these batch scale experiments, it is challenging to choose an optimal condition for the production of bio-crude from sewage sludge, because, in continuous HTL processing, a lot of other aspects need to be considered.*

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