Microwave-assisted HTC and gasification: Circular solutions for waste-to-Energy

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WOOD2WOOD

INTRODUCTION & METHODOLOGY

The Wood2Wood (W2W) project aims to valorise wood industry residues (sludges and wood waste) into H_2- and CO_2-rich syngas for further biochemical upgrading into detergents.

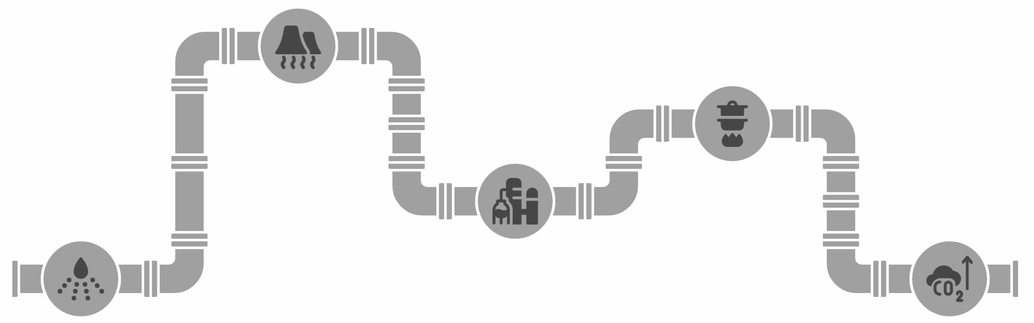
For so, a two-step strategy is being followed:

- **MW-HTC: Converts high-moisture sludges (Paper & pulp industry sludge, PPS) into hydrochar.**
- **Fluidised-bed gasification: Converts hydrochar and waste wood into clean syngas, seeking for hydrogen and carbon dioxide maximization, for further fermentation steps.**

This syngas is then subjected to a fermentation stage to produce dodecanol

The key process parameters studied are:

- **MW-HTC: residence time, temperature, solid %**
- **FB-Gasification: process temperatures, equivalence ratio, steam ratio**



01 **Wet Industrial Residues**
Initial input of wet industrial residues such as sewage or paper industry sludge

02 **Microwave Assisted Hydrothermal Carbonization**
Residues undergo carbonization in a microwave assisted reactor

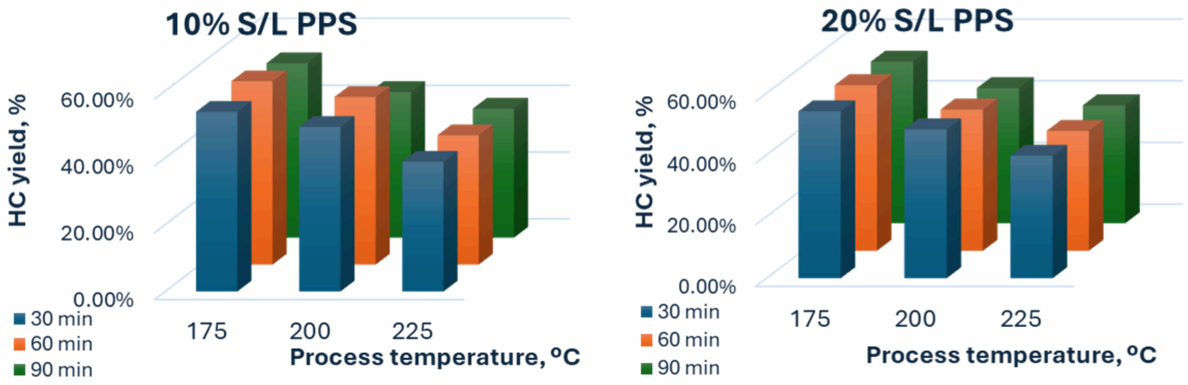
03 **Hydrochar Production**
Hydrochar is produced as a result

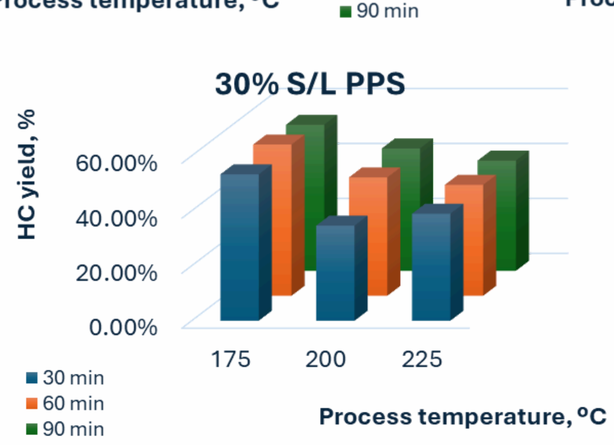
04 **Air and Steam Gasification**
Hydrochar is gasified with air and steam

05 **Maximize H2 and CO2 Content**
Aim to increase hydrogen and carbon dioxide content by modifying operating conditions

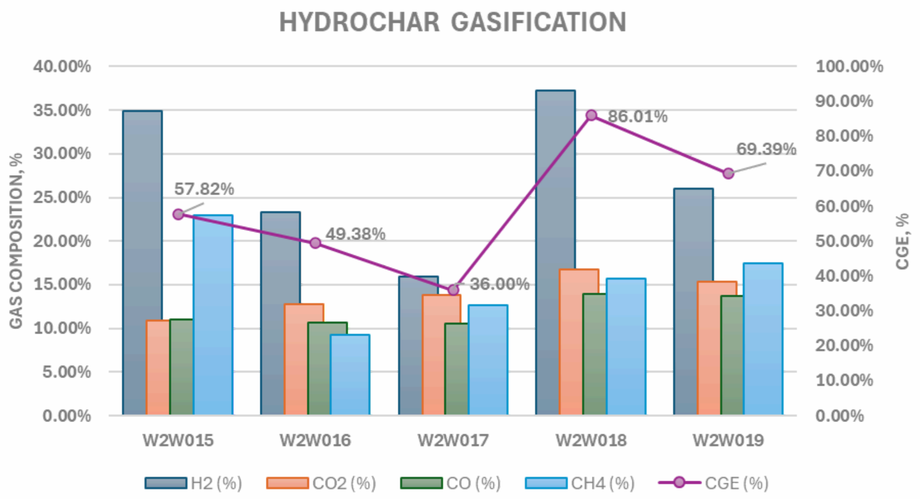
RESULTS

MW-HTC





FB GASIFICATION



Code	Bed temperature (ºC)	Freeboard temperature (ºC)	SR (%)	Steam flow (kg/kg)	CGE (%)	H_2 (%)	CO_2 (%)	CO (%)	CH_4 (%)	LHV Gas (MJ/Nm^3)
W2W015	329.60	855.31	8.51%	0	57.82%	34.96%	10.88%	10.95%	22.93%	13.08
W2W016	476.92	872.41	12.00%	0	49.38%	23.26%	12.72%	10.69%	9.21%	7.16
W2W017	425.00	850.00	9.00%	0	36.00%	15.88%	13.85%	10.49%	12.68%	7.65
W2W018	343.67	826.96	3.90%	0.4	86.01%	37.19%	16.74%	13.98%	15.75%	11.43
W2W019	360.07	789.28	5.52%	0.6	69.39%	25.95%	15.38%	13.66%	17.44%	10.19

CONCLUSIONS

- **Higher temperatures (225 °C) consistently reduced hydrochar yield due to increased solubilization of solids into the liquid phase.**
- **Longer residence times negatively affected hydrochar yield.**
- **Hydrochar from PPS showed higher fixed carbon and lower ash content than from sewage sludge, making it a more promising feedstock for downstream gasification.**
- **Steam injection (0.4–0.6 kg/kg) significantly improved hydrogen yield, with up to 37.2%.**
- **Lower bed temperatures (~330–350 °C) combined with high freeboard temperatures (>825 °C) are optimal for H_2-rich syngas from hydrochar.**
- **The high ash content and low H/C ratio of hydrochar indicate steam gasification is more effective than air gasification for this feedstock.**

A cascade valorisation approach combining MW-HTC and gasification is viable for treating moist wood-industry residues.
MW-HTC is an efficient method to convert wet sludges into hydrochar with improved energetic properties and reduced water retention.
Fluidised-bed gasification of hydrochar produces syngas streams rich in H_2 and CO_2, meeting the needs of downstream microbial fermentation.
Steam gasification enhances H_2 output compared to air gasification.

NEXT STEPS

Scale-up tests for MW-HTC experiments in 1-litre reactors and comparison with conventional HTC to assess microwave-specific benefits.
Integrate a water–gas shift reactor to enrich syngas in H_2 and decrease CO content, tailored for microbial uptake.

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