MSW Pyrolysis integrated with Anaerobic Digestion

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Aston University

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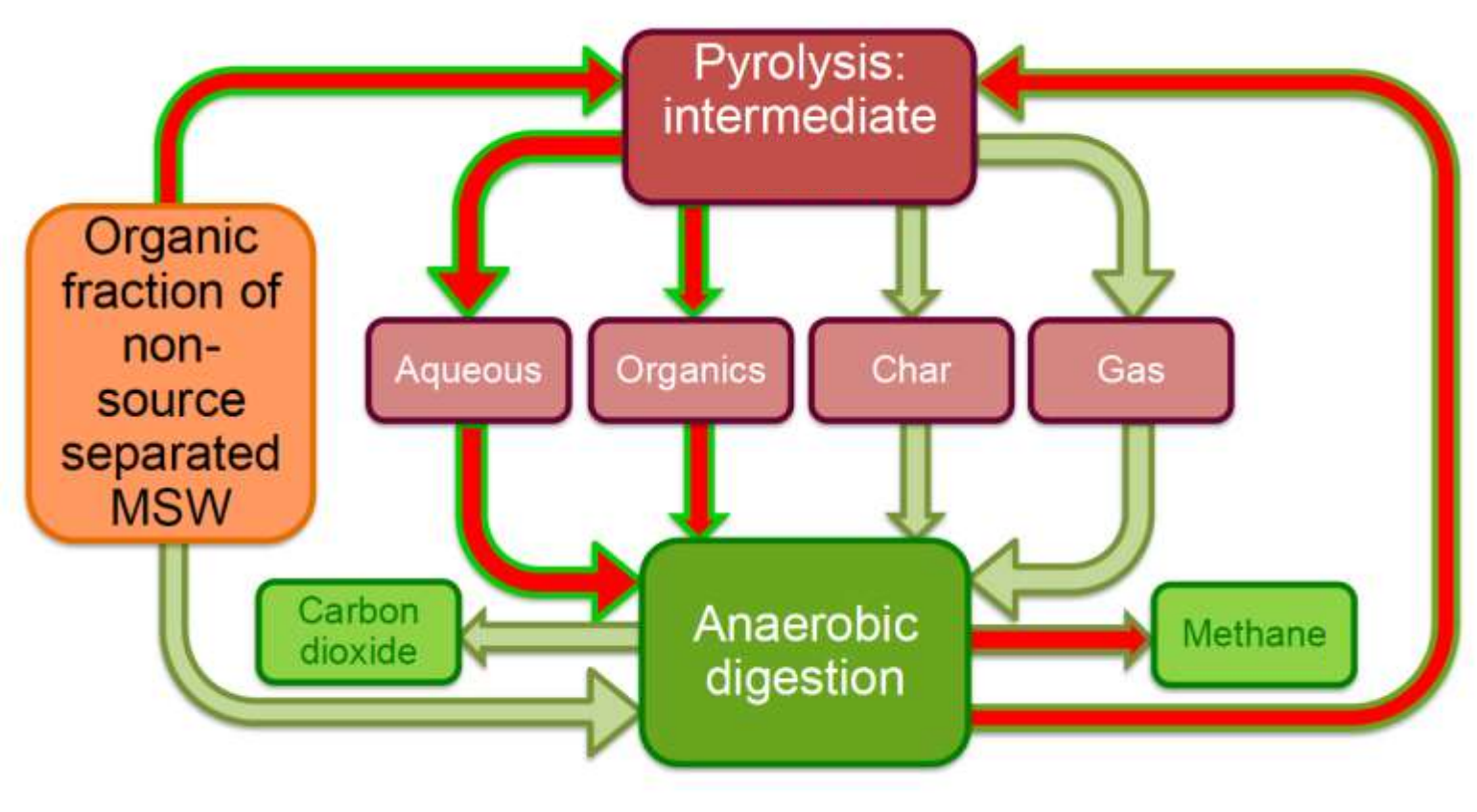
CONCEPTUAL Pyro-AD PROCESS



The aim of this project is to explore the synergy between biological (AD) and thermal (intermediate and slow pyrolysis) conversion processes to increase the overall net energy yield from the organic fraction of municipal solid waste.

FEEDSTOCKS

Composition of OFMSW (dry material basis)

Component	Content
Decomposed material (paper, food, fiber etc.)	68.6 wt.%
Plastics	6.5 wt.%
Glass	2.9 wt.%
Biomass waste	1.9 wt.%
Metal	1.2 wt.%
Cloth	1.0 wt.%
Coated Paper	0.2 wt.%
Stones and Ceramic	0.2 wt.%
Unknown Particles	17.5 wt.%

FEEDSTOCKS

Components of OFMSW

FEEDSTOCKS

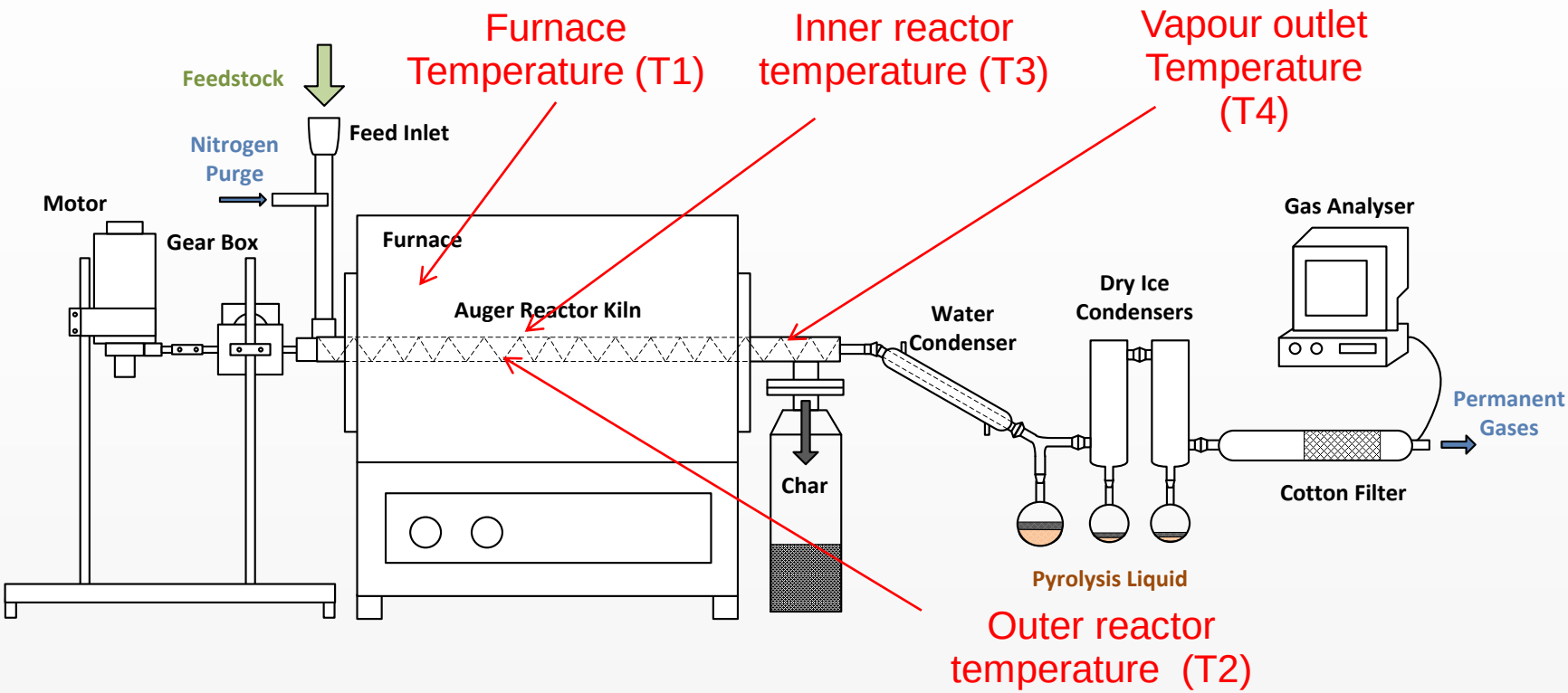
Feedstock Analysis (dry mass basis)

Ultimate analysis[1]	Unit	Value		Proximate analysis	Unit	Value
C	wt.%	35.1		Moisture[2]	wt.%	45.8
H	wt.%	4.7		Volatiles[1]	wt.%	51.1
N	wt.%	1.4		Fixed carbon[1]	wt.%	6.3
S	wt.%	0.2		Ash[1]	wt.%	42.6
O	wt.%	16.1		HHV	MJ/kg	15.4

[1] Dry basis; [2] Wet basis

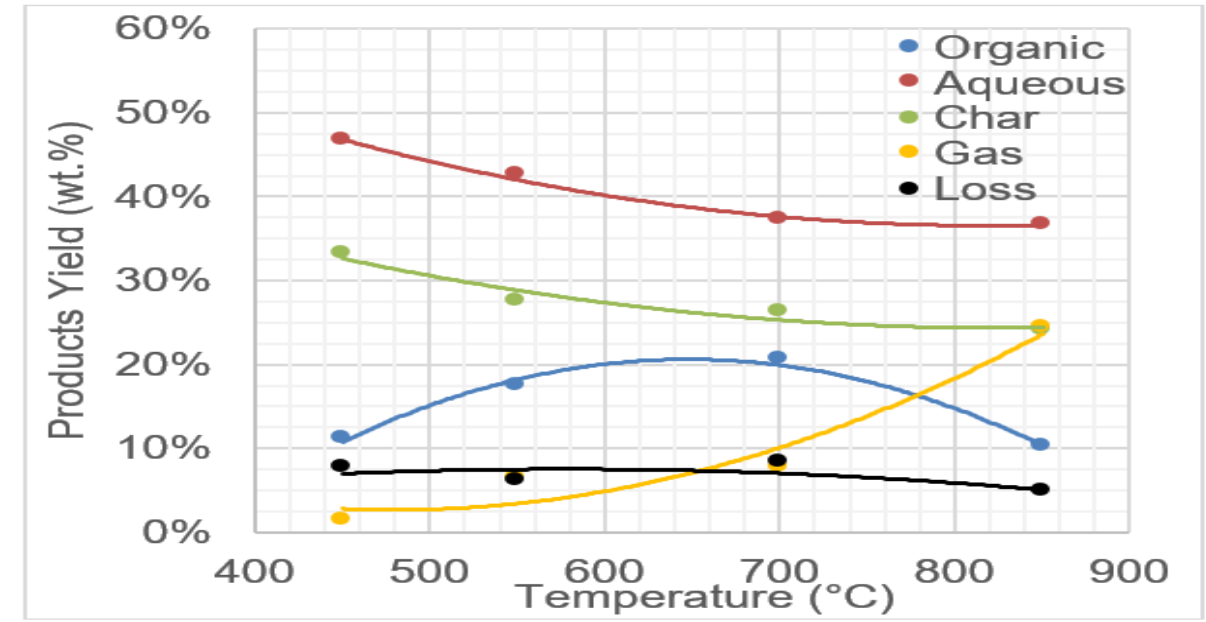
Very high moisture and high ash content feedstock

AUGER REACTOR (300g/h)



- Solid residence time in the reactor is about 6 mins at a feed rate of 350g/h
- Vapour residence time in the reactor is about 5 seconds
- Processing condition: Feedstock moisture content 45.8, 35.2, 22.7 and 12.7 wt% wet basis, Processing temperatures: 450, 550, 700 and 850 °C.

MASS BALANCE

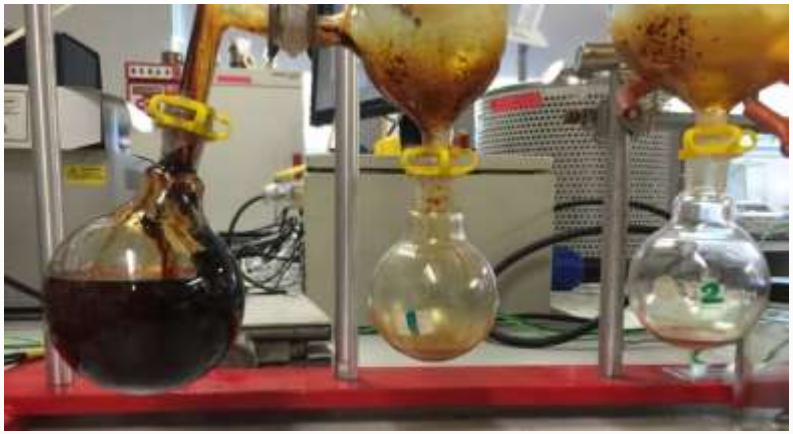


Results of 45.8% feedstock MC.

Results of mass balance on dry basis from other feedstock MC runs are very similar

- For each runs, 700 g feedstock processed in 2 hours
- Yields of aq product reduced with increase of processing temperature.
- Yields of gas increased significantly with increase of processing temperature
- Mass balance loss less than 10%. Loss happened in minor gas leaking and residues remained in condensation system.

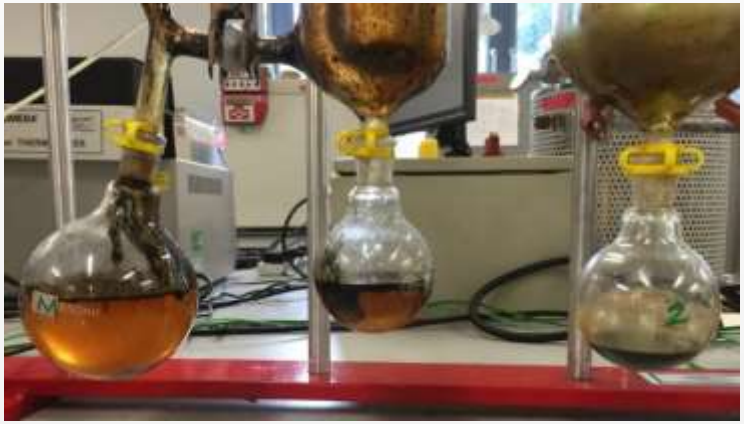
LIQUID PRODUCT



45.8 wt.% MC, 450°C

45.8 wt.% MC, 550°C

45.8 wt.% MC, 700°C

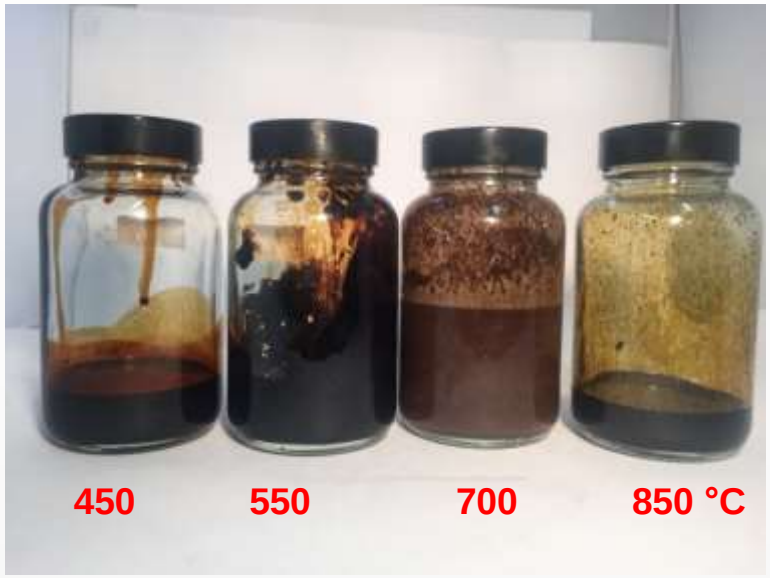


45.8 wt.% MC, 850°C

LIQUID PRODUCT

Aqueous Phase

45.8 wt.% MC Feedstock



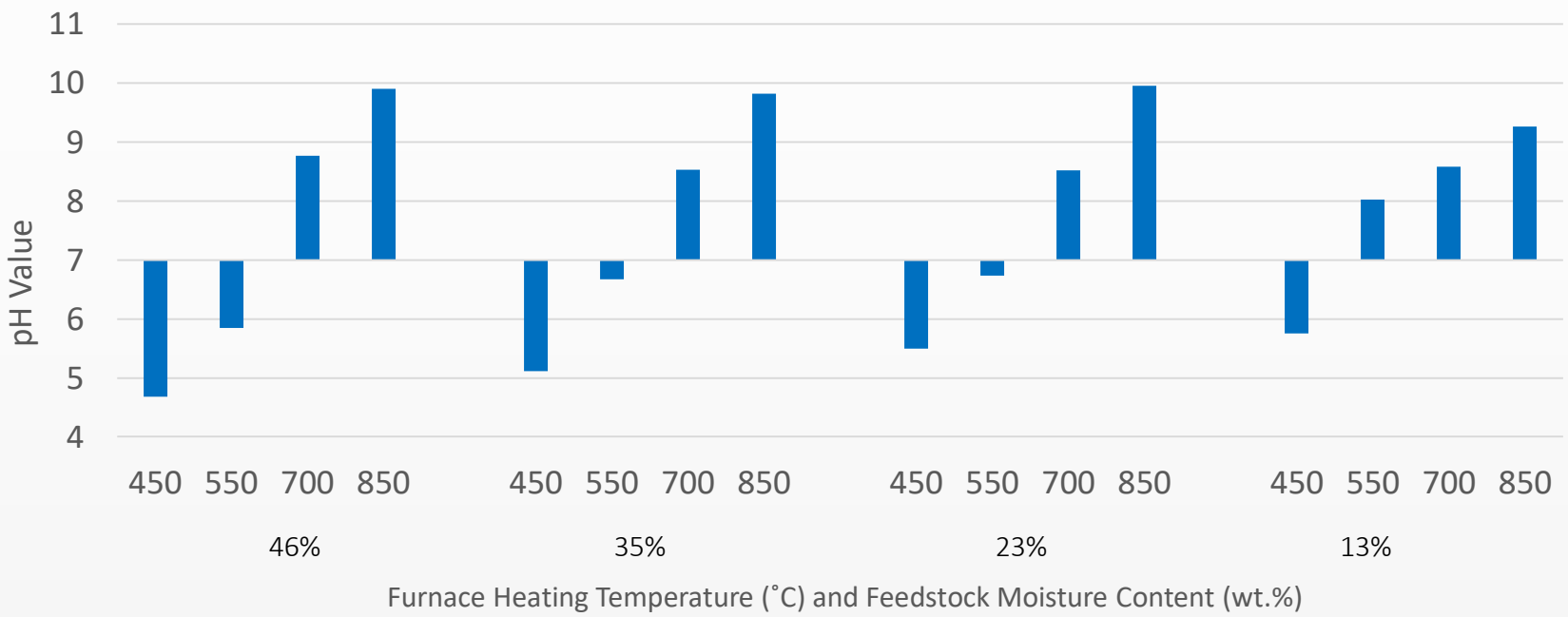
Organic Phase

45.8 wt.% MC Feedstock

The heating values of the organic phase samples decrease with the increase of pyrolysis heating temperature- ranging from about 13 to 32 MJ/kg.

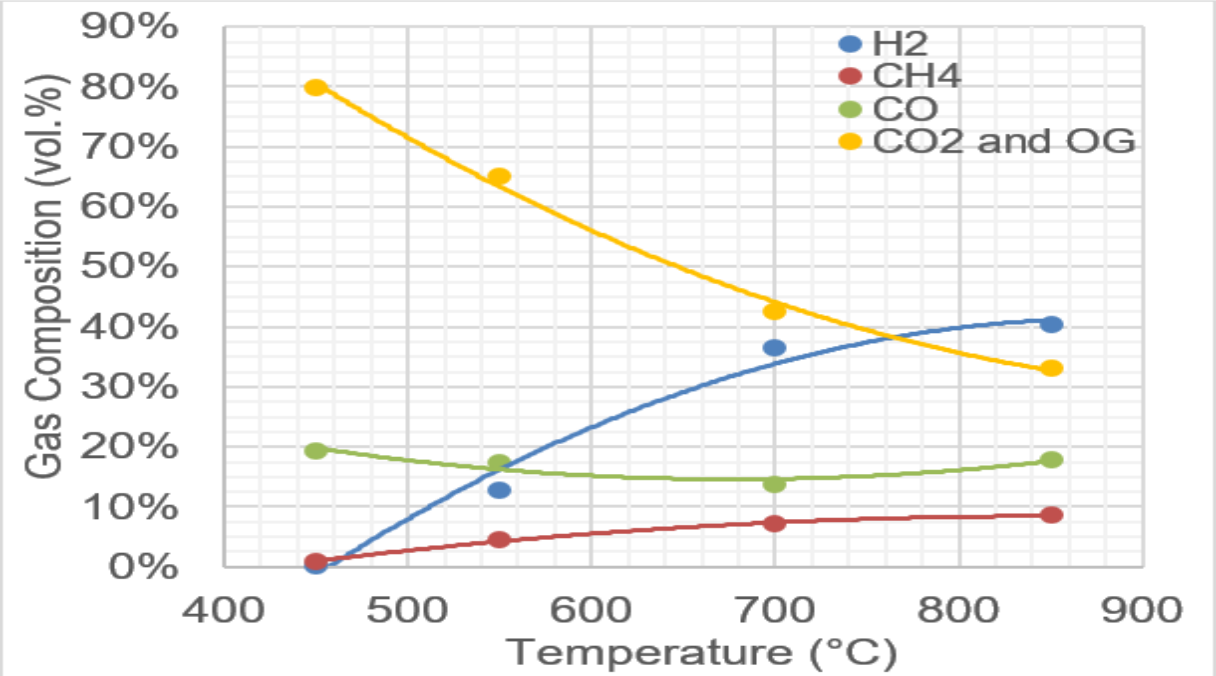
LIQUID PRODUCT

pH values of the aqueous phase samples



The pH values of the aqueous phase samples increase significantly with the increase of pyrolysis heating temperature- ranging from about 4.5 to 10.

PYROLYSIS GAS



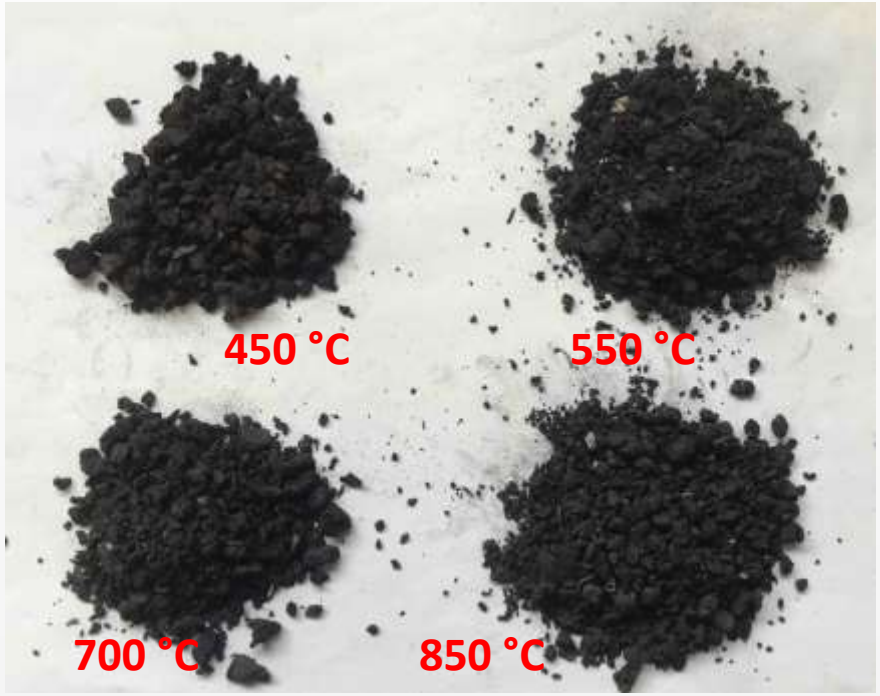
Results of 45.8% feedstock MC.

With the increase of processing temperature

- H2 production significantly increased
- CO2 production significantly reduced

CHAR

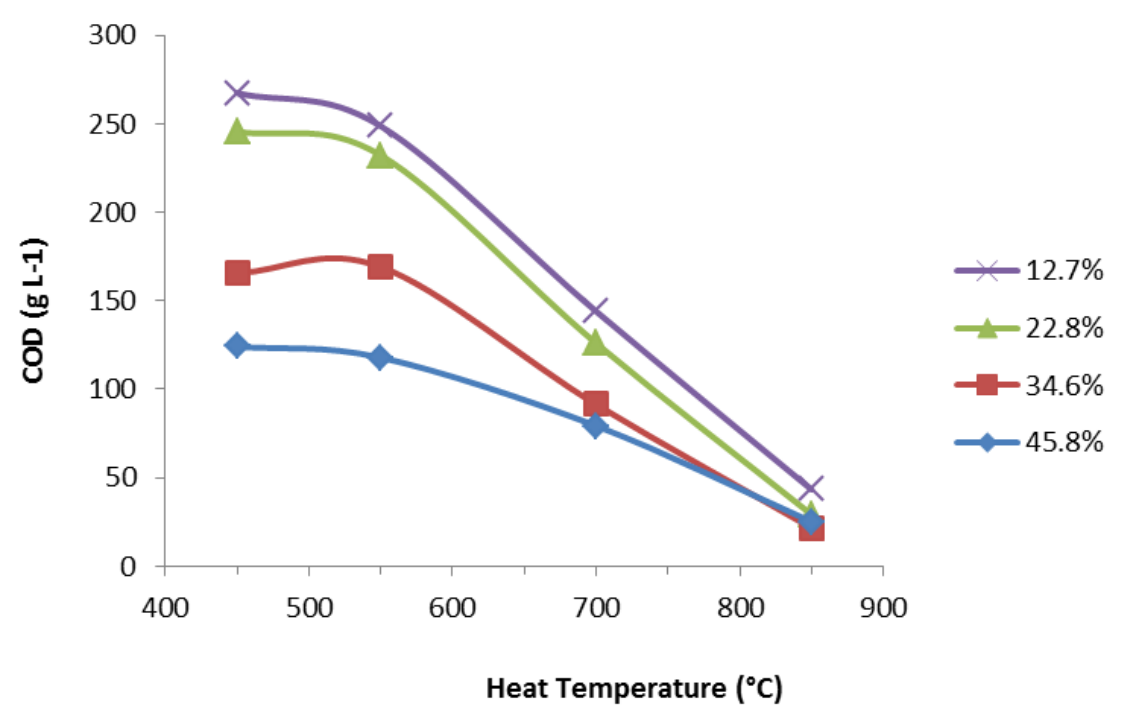
Comparison of char from feed MC 45.8% at different heating temperatures



Elemental Analysis

	C	H	N	S	O	Ash%
450°C	29.0%	2.6%	0.8%	0.5%	10.8%	56.2%
550°C	18.6%	1.2%	0.4%	0.5%	7.8%	71.4%
700°C	15.1%	0.5%	0.2%	0.3%	4.7%	79.0%
850°C	11.0%	0.4%	0.1%	0.4%	0.6%	87.6%

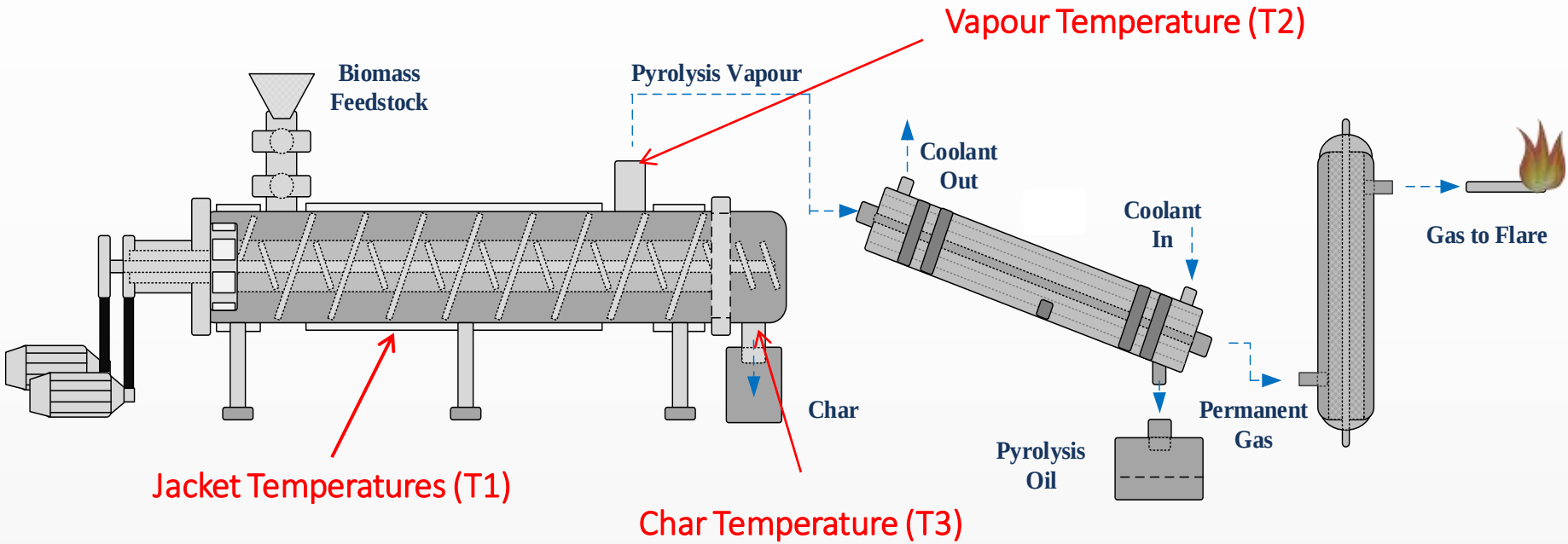
COD TESTS



COD tests on the aqueous liquid pyrolysis products

- High feedstock MC gives low COD at same processing temperature.
- Under high processing temperature, organic content in aq liquid is low and not worth to recover.

PILOT SCALE RUNS (10kg/h)



Products from this pilot scale system gave very similar results as the 300 g/h auger reactor under the processing temperature and feedstock MC

AD TESTS

- Operation: 120 days
- pH: 7.0-7.5 for all ratios of mixtures
- Methane: 40-60 %
- Alkalinity: ~ 8-10 g $CaCO_3$/L

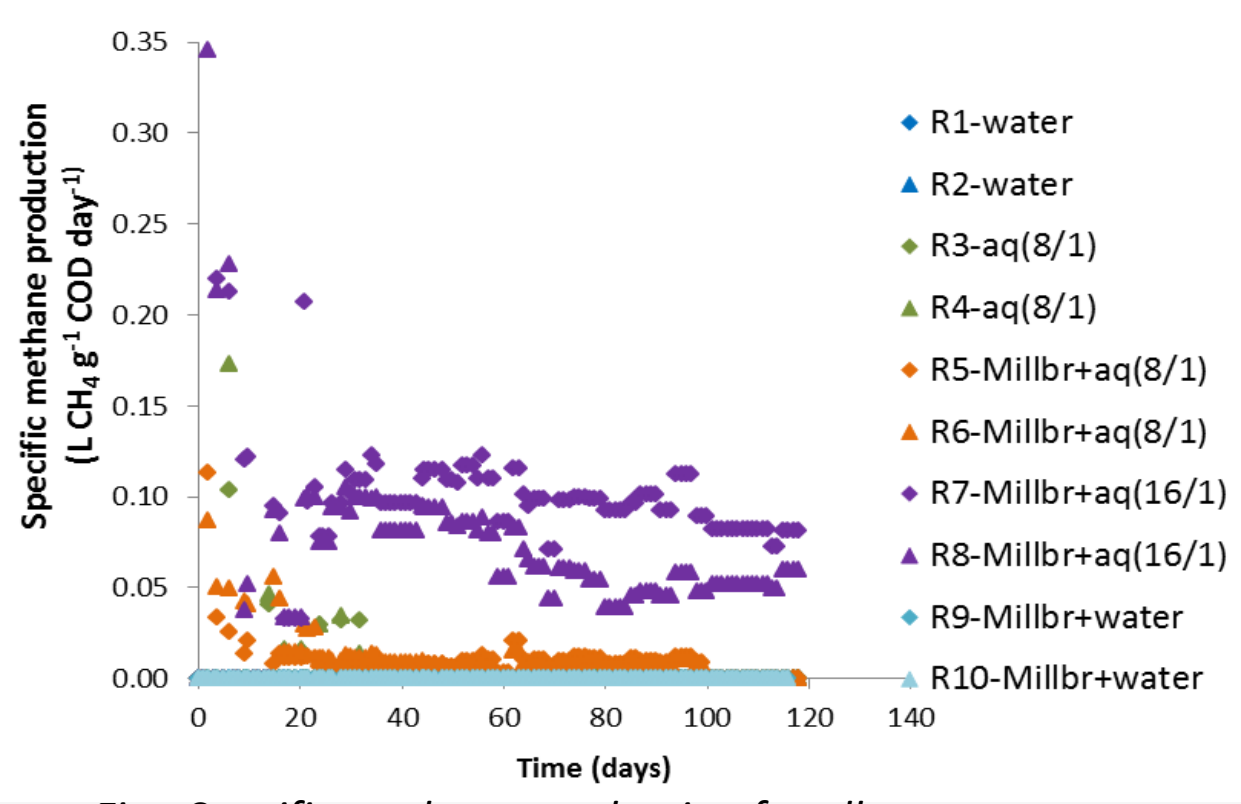


Fig.: Specific methane production for all reactors

16/1 inoculum to substrate ratio maintained lower levels of VFA (mostly acetic, 2500-3000 mg/L), which after 90 days of operation gradually decreased.

CONCLUSIONS

- Organic liquid product: contains mainly heavy organic compounds and could not be digested. Highly viscous, presents similar characteristics to bitumen.
- Aqueous liquid product: contained 1.2–13.1% of the energy in the original OFMSW feedstock. It could be digested, but only around 50% was convertible to methane.
- Pyrolysis gas: contains high proportion (volume ratio) of combustible gases in gasification temperature (850 °C): up to 40% H_2, 25% CO and 10% CH_4
- Char: high ash content char, up to 75%. Could be used in the AD, but it contains contaminants such as metals, glass, sand etc. which would need removal.

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Thank You