

Introduction



There is growing interest in the use of biomass feedstocks for low carbon energy, waste management & reduced fossil fuel dependence.

Pyrolysis & gasification convert a range of carbonaceous fuels into a variety of products.

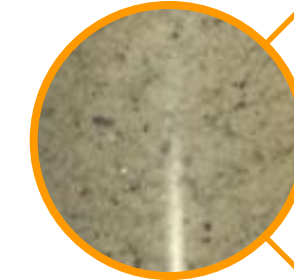


Gasification yields a mixture of CO, H₂, CH₄ & hydrocarbons which can be used to produce power or chemical feedstock [1].

Pyrolysis processes offer an alternative route to fuels and chemicals which would otherwise be derived from crude oil [2].



Feedstocks



RDF (Refuse Derived Fuel) comes from processed municipal solid waste. It is highly abundant but its mixed nature can pose technical challenges.



Waste wood from construction and demolition operations, pellets, retail, and municipal collections is readily available as a bioenergy source.



Willow sourced from short rotation coppicing is estimated to be produced at ~66000 t yr⁻¹ in the UK so its potential for large scale applications is limited

Table 1: Proximate and ultimate analysis of biomass feedstocks

wt%, as received	RDF	Waste wood	Willow
Moisture	4.31	6.73	6.43
Volatiles	71.83	79.24	71.18
Ash	12.78	0.76	2.90
Fixed carbon*	11.08	13.27	19.49
Carbon	45.05	45.96	49.94
Hydrogen	6.36	5.30	6.07
Nitrogen	0.53	0	1.09
Sulphur	0.04	0	0
Oxygen*	30.72	41.25	35.57
*by difference			
HHV (MJ/kg)	18.83	19.45	20.24

Experimental

First stage reactor: 2 g of feedstock heated to 500 ° C

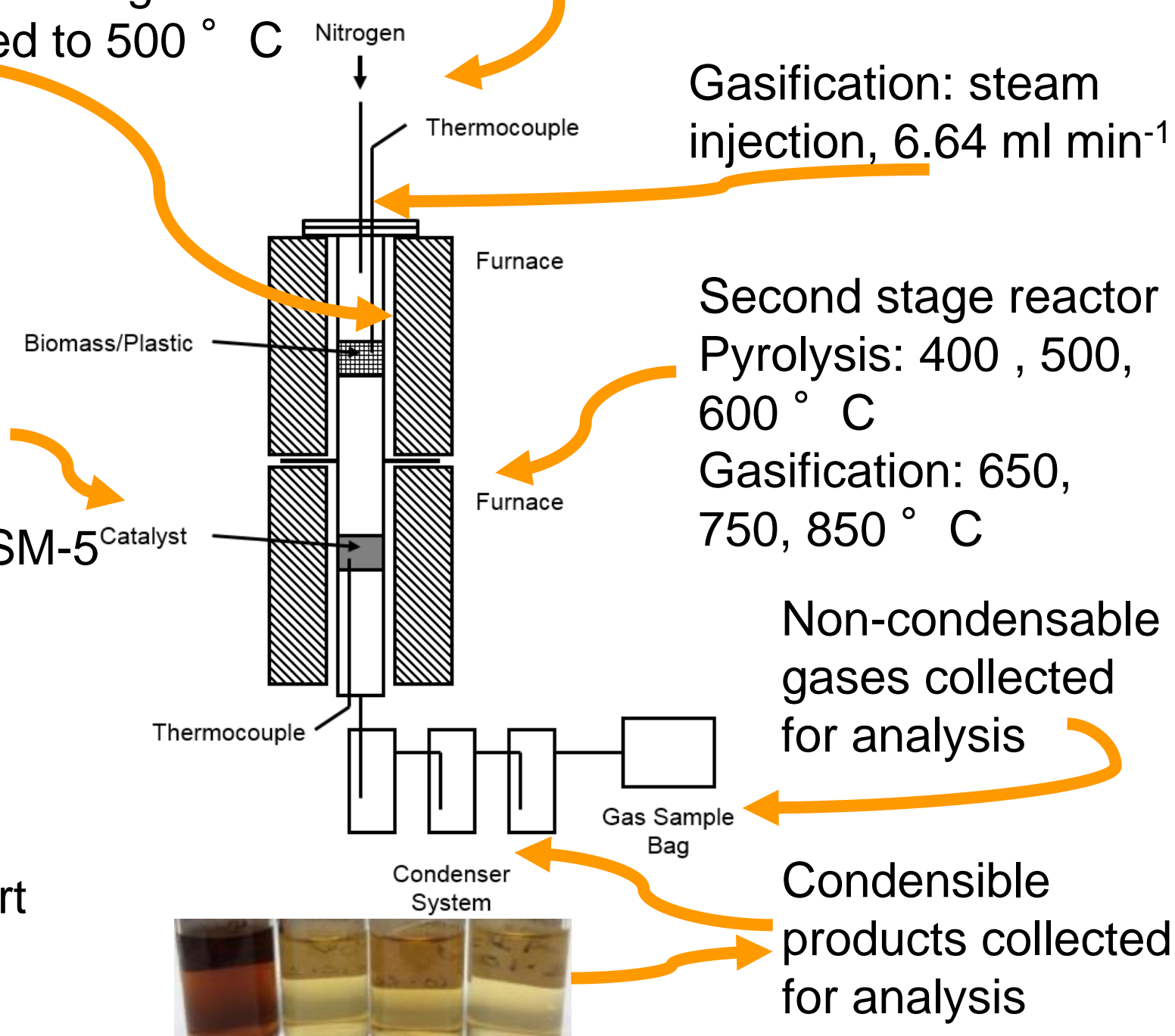
Carrier gas: nitrogen, 200 ml min⁻¹

Gasification: steam injection, 6.64 ml min⁻¹

Second stage reactor
Pyrolysis: 400, 500, 600 ° C
Gasification: 650, 750, 850 ° C

1 g of catalyst.
Pyrolysis:
1 wt% Ni on ZSM-5 support

Gasification:
5 wt% Ni on alumina support



Pyrolysis Oils

- Waste wood – mixture of bulky & heteroaromatic compounds. Some cyclic aliphatics.
- MSW – C₁₃ – C₂₂ saturated hydrocarbon chains & some double aromatics. Deoxygenation.
- Willow SRC – No straight hydrocarbon chains, mostly small aromatics.

Feedstock	Peak %				
	All single aromatics	Single aromatics*	Double aromatics	Chains	Non-chains (non-aromatic)
Waste wood	61.43	42.27	0.00	23.63	14.91
RDF	13.25	0.00	22.04	64.71	0.00
SRC willow	90.90	6.05	8.11	0.00	0.98

Table 2: Composition of pyrolysis oils



Gasification: Syngas Production

Composition:

No C₂-C₄ and a small amount of methane.
The main products: CO₂, CO and H₂.

Overall gas yield:

Waste wood gasification gas yield ~ 100%.
Gasification of willow → lowest overall gas yield.

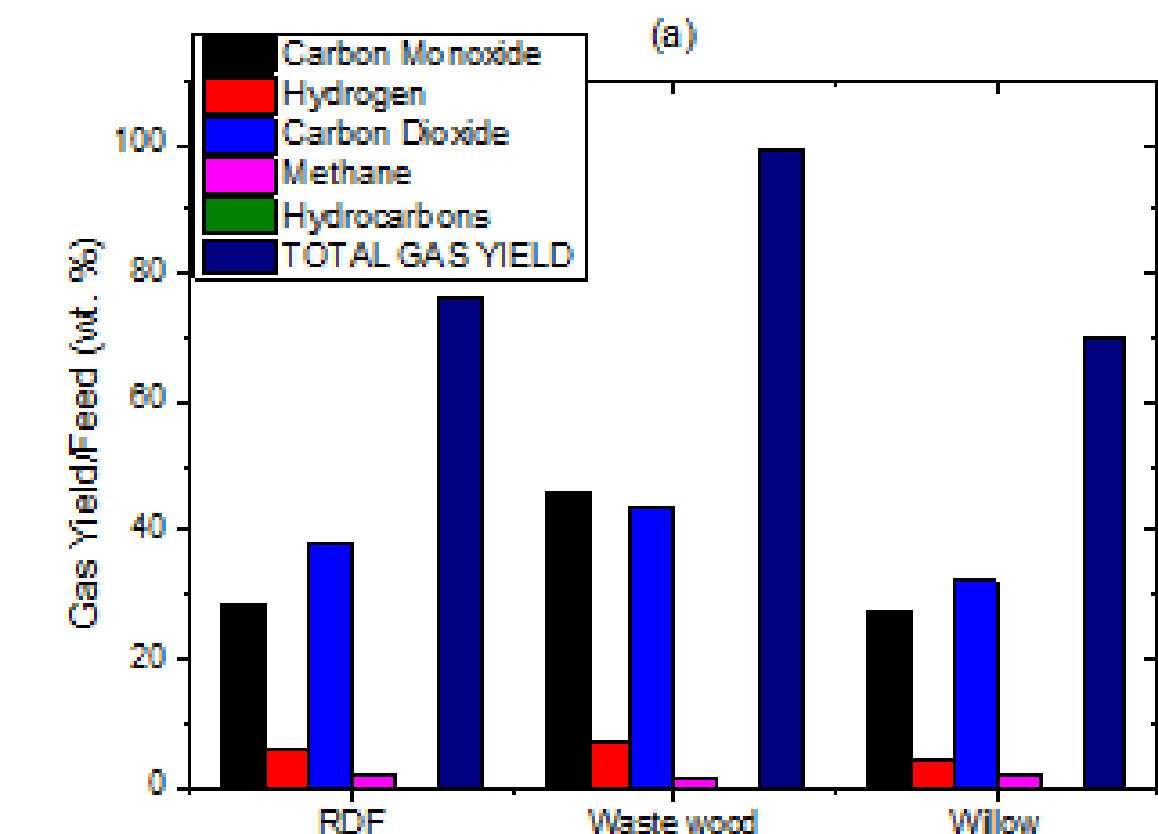


Figure 1: Gasification Gas Yields

Conclusion

	RDF	Waste wood	Willow
UK feedstock availability	Most abundant	Relatively large resource available	Insufficient to sustain commercial-scale operations
Gasification	Higher hydrocarbon content	Highest gas yield	Lower syngas production
Pyrolysis	Straight chain hydrocarbons. Potential for upgrading to diesel-like transport fuel.	Single aromatics. Some bulky hydrocarbon chains	Single aromatics Potential for upgrading to high value chemical feedstocks.

References

- [1] Woolcock, P.J. and Brown, R.C. A review of cleaning technologies for biomass-derived syngas. *Biomass and Bioenergy*. 2013, **52**, pp.54-84.
- [2] Venderbosch, R.H. et al. Stabilization of biomass-derived pyrolysis oils. *Journal of Chemical Technology & Biotechnology*. 2010, **85**(5), pp.674-686.