

Pyrolysis of Biomass

Conversion Methods

Biomass can be converted into heat and electricity in a number of ways. Depending on its source, these processes include: **combustion**, **pyrolysis**, **gasification**, liquefaction, **anaerobic digestion or fermentation**.

Thermo-chemical processes convert biomass into higher-value or more convenient products. The process releases **a gas** (~ 6 MJ/kg), **a liquid** (~ 17 - 22 MJ/kg) and/or **a char** (~ 18 MJ/kg), and depending on the technology one of these is the final product.

Thermochemical Methods



Co-firing



Direct combustion



Gasification

Liquefaction

Pyrolysis



Pyrolysis

- Pyrolysis is a thermochemical decomposition of organic material at temperatures between 400 ° C and 900 ° C without the presence of oxygen or other reagents.
- The pyrolytic breakdown of wood produces a large number of chemical substances.
- Some of these chemicals can be used as substitutes for conventional fuels.
- The distribution of the products varies with the chemical composition of the biomass and the operating conditions.

Slow Pyrolysis : Primarily to produce Char through Carbonization

Utilizes low temperatures around 400 °C over a long period of time to maximize char formation.

Product yields from slow pyrolysis are approximately

35% biochar,

30% bio-oil, and

35% gaseous products.

Rapid/Fast Pyrolysis : Primarily to produce Bio-Oil and Gas

-Biomass is very rapidly heated ($\sim 1000-10,000$ °C/s) to a temperature around 650 °C- $1,000$ °C depending if bio-oil or gas products are desired.

-Product gases are quickly removed and quenched ($t < 2s$)

Fast pyrolysis product yields are typically 50–70% bio-oil, 10–30% bio-char, and 15–20% syngas by mass.

Biomass must first be dried and ground to < 2 mm particle size before entering a fast pyrolyzer.

Pyrolysis Parameters

- Biomass type and preparation of feeding
- Pyrolysis temperature
- Catalyst
- Sweeping gas velocity
- Particle size
- Reactor geometry
- Heating rate

Bio-Oil

Bio-Oil is not stable as conventional fuels.

- Highly oxygenated compounds
- High density
- High viscosity
- Low pH
- Low heating value
- CO₂ neutral
- No SO_x and low NO_x

Bio-Oil can be combusted directly in boilers, gas turbines and slow and medium speed diesels for heat and power applications.

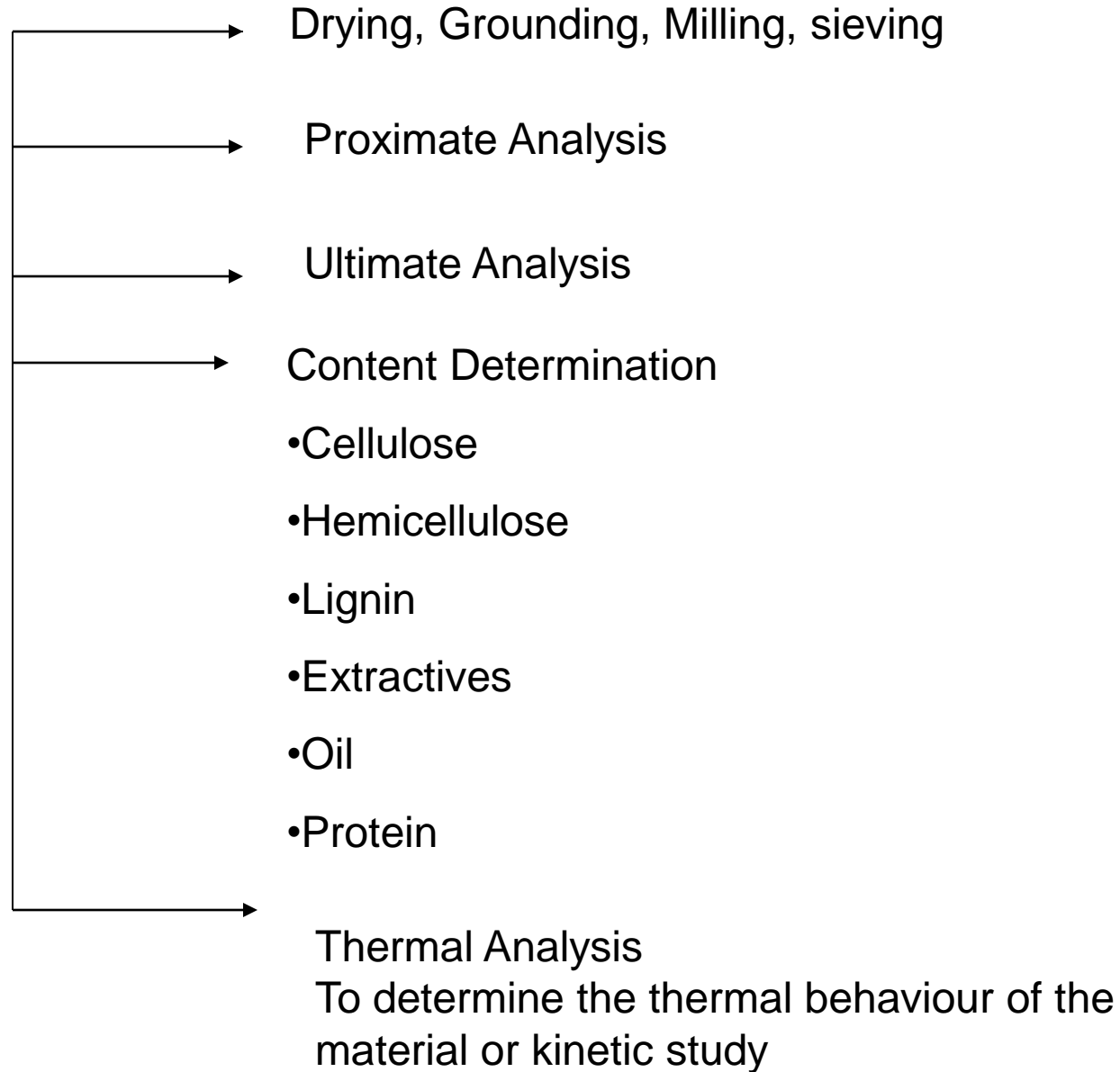


Comparison of pyrolysis liquid and conventional fuel oil characteristics*

	Pyrolysis liquid	Diesel	Heavy fuel oil
Density kg/m³ at 15°C	1220	854	963
Elemental Composition			
% C	48.5	86.3	86.1
% H	6.4	12.8	11.8
% O	42.5	---	---
% S	---	0.9	2.1
Viscosity cSt at 50°C	13	2.5	351
Flash point °C	66	70	100
Pour point °C	-27	-20	21
Ashwt.%	0.13	0.01	0.03
Sulphur %wt	----	0.15	2.5
Water %wt	20.5	0.1	0.1
LHV(MJ/kg)	17.5	42.9	40.7
Acidity	3	---	----

APPLIED ANALYSES

Raw material



Analyses Applied on Products

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graph TD; A[Analyses Applied on Products] --> B[Bio-oil]; A --> C[Bio-Char]; A --> D[Gaseous product];
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Bio-oil

- *Elemental analysis/
Bomb Calorimetry
- *FT-IR
- *H-NMR
- *GC-MS
- *Adsorption
Chromatography
- *Karl Fischer titration-
water separation
- *ICP

Bio-Char

- *Elemental Analysis/
Bomb Calorimetry
- FT-IR
- BET
- SEM
- C¹³-NMR
- ICP

Gaseous product

- *Bomb Calorimetry
- *GC

Compositions of Products

Contamination of bio-oil

Acids, Esters, Alcohols, Ketones, Aldehydes, Phenols, Alkenes, Aromatics, Nitrogen compounds, Furans, Syringols, Sugars, Miscellaneous oxygenates
Inorganics such as Ca, Si, K, Fe, Al, Na etc.

Composition of gaseous products

CO, CO₂, CH₄, H₂, propane, propylene, butane, butenes, C₅, ethane, etc.

Composition of Char

Char contains elemental carbon along with hydrogen and various inorganic species.

BIO-CHAR

Biochar carbon-rich solid produced at low pyrolysis temperatures.

- process heat
- activated carbon
- ❖ soil amendment



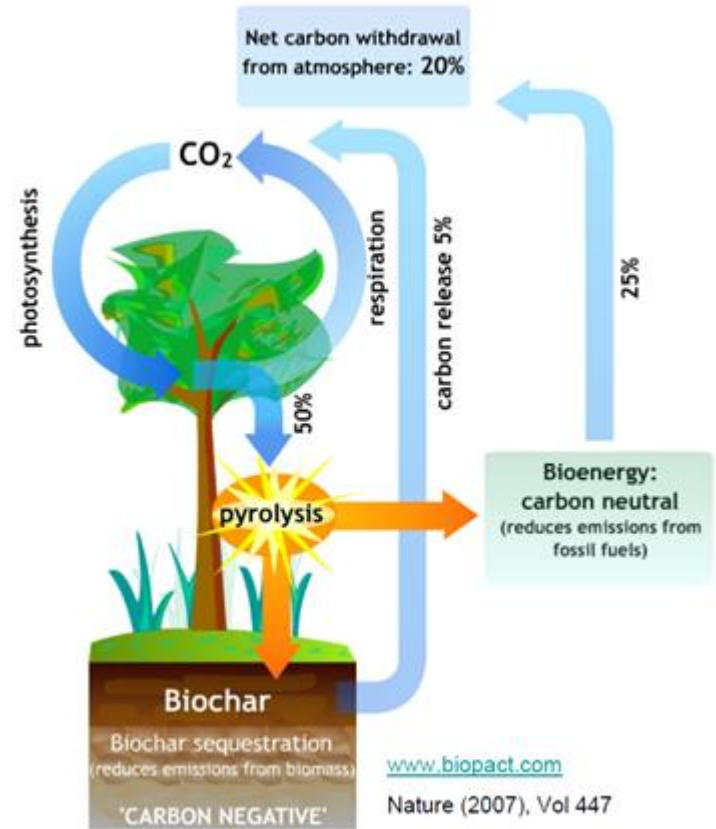
Negative carbon cycle

When biochar is stored in soils to make them more fertile, the biofuels carbon cycle is negative.

Application to the soil, in conjunction with bioenergy generation, can result in carbon sequestration.

Biochar is relatively stable that can be used to increase the soil organic contents of eroded areas.

Adding these materials may make a longer term impact on the soil productivity.



FUTURE

Pyrolysis is considered to be one of the sustainable solution that may be economically profitable in large scales and minimise environmental concerns especially in terms of

Waste minimization

Carbon sequestration

Soil amendment

Energy/heat supply

Value added chemicals

Development of rural areas