OVERVIEW OF BIOMASS PYROLYSIS

WV Department of Agriculture BioEnergy Forum

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WHAT IS PYROLYSIS?

A THERMOCHEMICAL PROCESS

WHERE ORGANIC MATERIALS

ARE HEATED TO HIGH TEMPERATURE

WITHOUT OXYGEN.

Pyrolysis? – A Matter of "Time & Temperature"

Pyrolysis

Thermal degradation of the polymeric components of biomass – mainly hemicellulose, cellulose and lignin

	Liquid	Char	Gas
FAST PYROLYSIS moderate temperature (~500C) short hot vapour residence time (<2 s)	75% mostly organics	12%	13%
SLOW PYROLYSIS Low-moderate temperature, long residence times	30% mostly water	35%	35%
GASIFICATION high temperature (>800C), long vapour residence time	5% tars	10%	85%

Bio-Oil Components

Chemicals in bio-oil

The chemicals in bio-oil are derived from random thermal decomposition of hemicellulose, cellulose and lignin.

Numbers of chemicals by group regularly identified in the literature:

Acids	12
Sugars	8
Aldehydes	5
Esters	1
Alcohols	4
Ketones	32
Phenolics	56
Oxygenates	16
Hydrocarbons	6
Steroids	15
	162

Specific Chemicals in Bio-Oil

Yields of chemicals - 1

Chemicals ranked by maximum reported yield, wt%

30.4	levoglucosan
15.4	hydroxyacetaldehyde
10.1	acetic acid
9.1	formic acid
8.5	acetaldehyde
5.2	furfuryl alcohol
5.0	catechol
4.0	methyl glyoxal
3.6	ethanol
3.2	cellobiosan
3.1	1,6-anhydroglucofuranose
2.9	fructose
2.8	glyoxal

2.4	formaldehyde
2.1	phenol
2.0	propionic acid
2.0	acetone
1.9	methylcyclopentene-ol-one
1.9	methyl formate
1.9	hydroquinone
1.7	acetol
1.6	angelica lactone
1.5	syringaldehyde
1.4	methanol
1.3	1-hydroxy-2-butanone
1.3	3-ethylphenol

Feedstock Requirements for Bio-Oil

Fast pyrolysis for liquids

Main feed requirements

- Dry to less than 10% water
- Reduce size to less than ~3mm

Main process requirements

- Heat biomass as quickly as possible,
- Control reaction temperature, typically 500C for wood,
- Cool vapours as quickly as possible,
- Minimise contact with char and ash in biomass – both are catalysts

Products

- Liquid

Moisture content	25%	C	56%
pH	2.5	H	6%
HHV as produced	17 MJ/kg	O	38%
Vacuum distillation residue	~ 50%		

- Byproducts

Charcoal	Use in-plant for heat or export
Gas	Use in-plant for heat

What is Fast Pyrolysis?

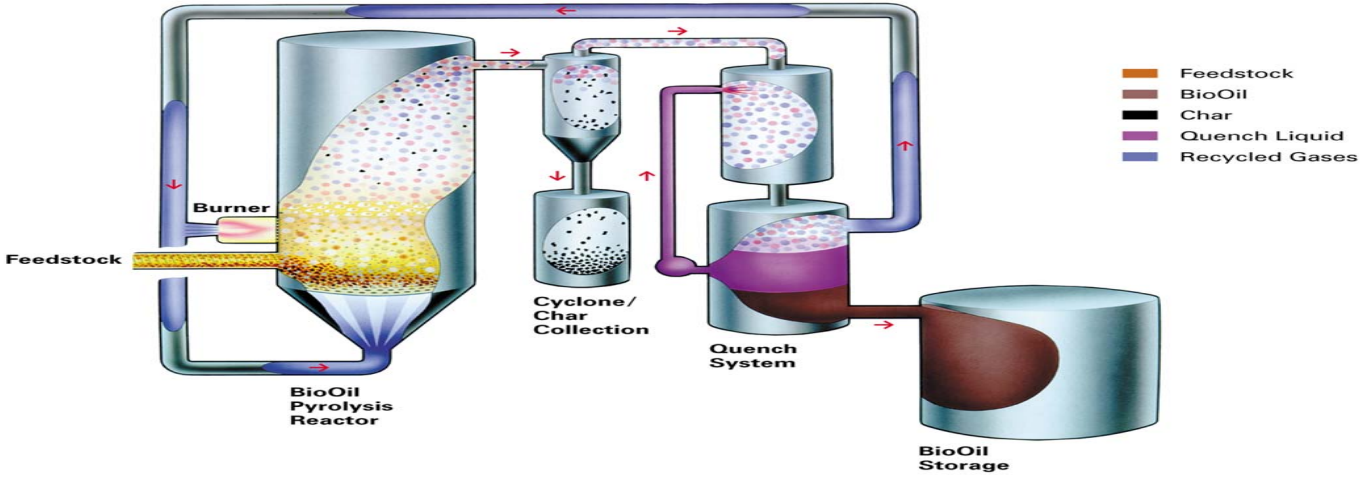
Dynamotive's Biomass to BioOil Process

Fast Pyrolysis: Rapid (< 2 seconds) heating of biomass in the absence of oxygen. Two commercial products:

BioOil (yield 55 – 73%) **Char (yield 15 – 25%)**

Non-condensable gases are recycled in the process.

Feedstocks - agricultural and forest residue including bark and whitewood, sugar cane residue, wheat straw, rice hulls **(over 120 feedstocks tested).**



Bio-Oil Plant in Canada

100 tpd Plant, West Lorne, Ontario, Canada

- 100% owned by Dynamotive
- Located at Erie Flooring and Wood Products
- World's largest BioOil fired co-generation plant up to:
  - 100 tpd of biomass input
  - 68 tpd BioOil output
    - 2.5 MW electricity
    - Excess BioOil sold
- Off-take agreements in place for entire plant output

Note: tpd = tonnes per day

Bio-Oil Potential from Logging Residues

- **Renewable Oil International, LLC**

  - **Modular, transportable fast pyrolysis units**
    - **"take the process to the biomass resource"**
    - **convert biomass to 'Distillate" and char**
      - **"Distillate" = transportable liquid fuel**
      - **char for charcoal briquettes or soil remediation**

  - **Technology "fits" sawmills**
    - **converts bark and sawdust residues to fuel and char**

  - **Technology "fits" forestry landing sites/clear-cutting sites**
    - **converts logging residues to fuel and char**

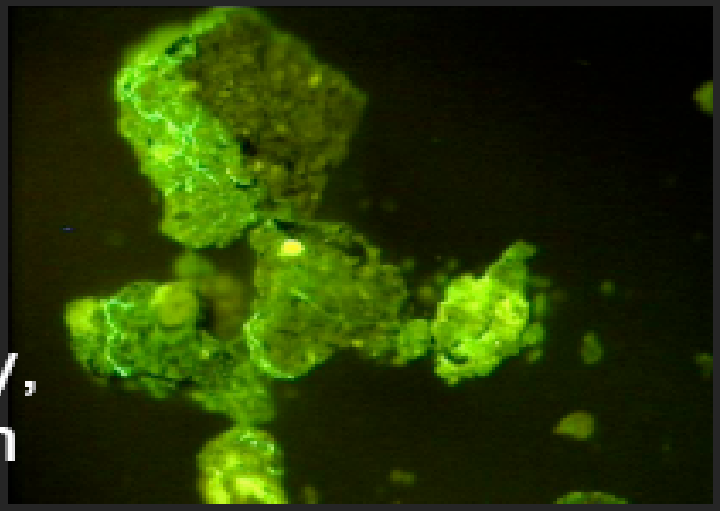
Char – What is it?

- The solid residue product of fast pyrolysis
- A micro-porous form of charcoal
- Contains all the mineral content of the biomass used to make it
- Slowly releases its mineral/nutrient content to the soil
- Provides friendly environment for soil micro-organisms, especially nitrogen-fixing species
- Builds fertility in sub-standard soils.
- Is frequently pelletted for fuel (young/green coal)

CHAR's Remarkable Properties

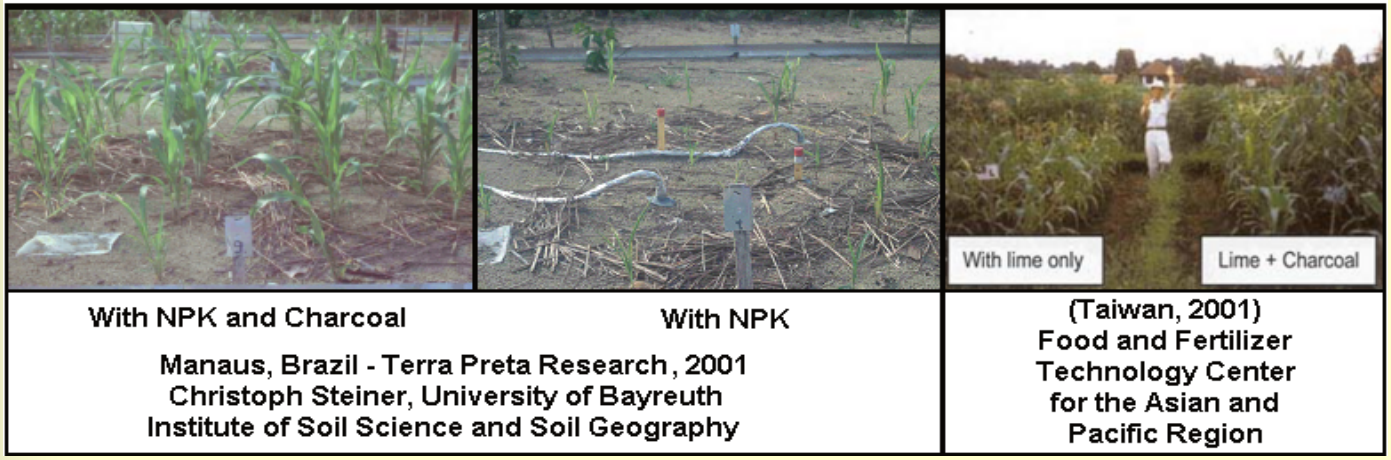
Fertile Soil is "aggregated"

- AM Fungi produce a glue Glomalin, which aggregates small soil particles
- This increases water and air holding capacity, resulting in soil tilth with increased biomass yields.



Char – A Valuable Soil Amendment

Global Charcoal Research



With NPK and Charcoal | With NPK

Manaus, Brazil - Terra Preta Research, 2001
Christoph Steiner, University of Bayreuth
Institute of Soil Science and Soil Geography

(Taiwan, 2001)
Food and Fertilizer
Technology Center
for the Asian and
Pacific Region

Other charcoal benefits

- Surface oxidation of the char increased the cation exchange capacity (Glaser)
- Char increased available water holding capacity by more than 18% of surrounding soils (Glaser)
- Char experiments have shown up to 266% more biomass growth (2nd Yr Steiner) and 324% (Kishimoto and Sugiura)
- Plant nitrogen uptake doubled in charcoal amended soils (Steiner)
- Charcoal has proven to help reduce farm chemical runoff (Yelverton)

Summary – Biofuels for West Virginia

- **Ethanol and biodiesel opportunities will depend on availability of locations with available infrastructure and favorable transportation infrastructure**
  - **Cellulosic biomass to ethanol still in the future**
    - **Its time will come – 5-7 years**
- **Bio-Oil/Distillate and char production from forestry and wood industry residues appears viable today**
  - **Particularly from low-value or waste biomass feedstock**
    - **Sawdust, bark, chips**