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Pyrolysis of Biomass

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In partnership with:
USDA Forest Service Region 5

http://ucanr.org/WoodyBiomass

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Making a Difference for California

Pyrolysis

- Pyrolysis is thermal decomposition occurring in the absence of oxygen
  - Energy required to raise temperature to start process (527F) may be external or internal (part of biomass load)
- It is the first step of combustion and gasification
- Family of related processes including:
  - Slow pyrolysis
  - Torrification
  - Torrefaction
  - Airless drying
  - Destructive distillation
  - Fast pyrolysis

Slow pyrolysis – batch carbonization

- Proven technology (1000+ years)
- Low temperature, long residence time (550-750^{o}F, 30mins-days)
- Flexible feedstock specification
- Burns part of the load for the heat input
- Charcoal is main product
- Equipment available for large and small scale production
- AQ issues
- Works in the woods!

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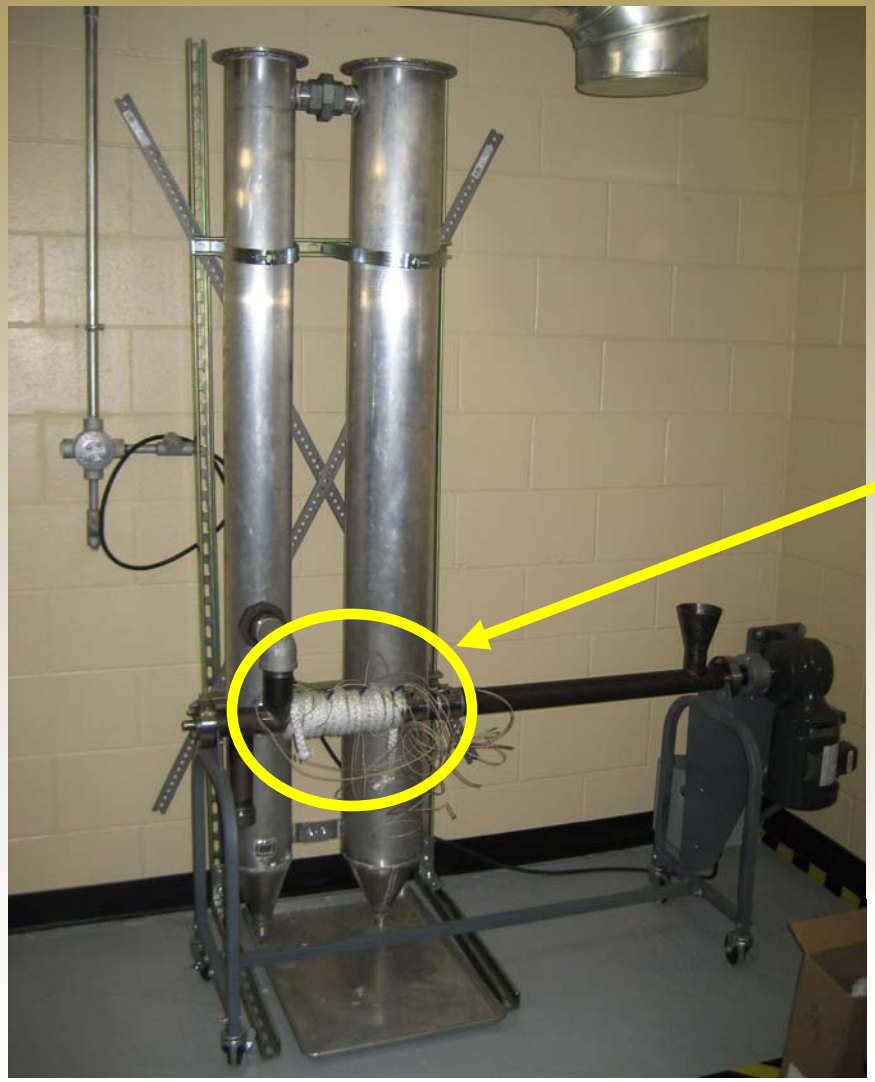
Slow pyrolysis – continuous auger system



External heat source (electricity)

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Other slow pyrolysis units

Industrial unit

- 20,000 ton/yr feedstock
- 5000 ton/yr charcoal
- 400kW electric generation

Small retort

- ~$30,000
- 250 tons/yr feedstock
- 62 tons/yr charcoal

www.fourseasonsfuel.co.uk

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Fast pyrolysis

- An emerging technology
- Moderate temperature, short residence time (930°F/~1s)
- Products are bio-oil, char (and gas)
- Tight feedstock specification (clean, $^{1}/_{16}$-$^{1}/_{8}$”, <10% moisture)
- Energy balance can be a problem (energy required for drying and process heat)

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Fast pyrolysis – ROI mobile equipment demo, Oregon, Aug ‘09

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Torrefaction or Torrification

- Mild pyrolysis
- 400-600^{o}F
- Product is char (“bio-coal”)
  - ~Loss of mass (cheaper transportation)
  - Higher energy density (10,500 BTU/lb vs 8,500 BTU/lb)
  - Hydrophobic (store outside)
  - Easier to grind than wood
  - Potential fuel for coal power plants
- Scale-up and financing is an issue

Pyrolysis outputs

1. Liquid (bio-oil - C, H, O and other constituents)
2. Char
3. Gas

Vary depending upon process conditions (residence time and temperature)…

Mode	Conditions	Liquid	Char	Gas
Fast pyrolysis	moderate temperature, short residence time particularly vapour	75%	12%	13%
Carbonisation (slow pyrolysis)	low temperature, very long residence time	30%	35%	35%
Gasification	high temperature, long residence times	5%	10%	85%

Source: PyNe

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Bio-oil

- Potential to substitute for conventional fuels in boilers, engines, turbines (*note*: may damage equipment, invalidate warranty)
- Heating value 40% of fuel oil/diesel (~17 MJ/kg at 25% wt. water)
- Does not mix with hydrocarbon fuels
- Acidic (pH 2.5)
- Not as stable as fossil fuels (storage issues)
- Needs further refining steps for most applications

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Char, Biochar, Charcoal, Torrefied wood

- Charcoal (lump or briquette) – barbeques, restaurants
- Filtration (water and air) using activated carbon
- Soil improvement
- Growth media (substitute for vermiculite)
- Fuel for coal (or other power plants)
- Prices vary with quality and end-use
- Artists charcoal, gasification, pharmaceuticals, animal feed, pyrotechnics, explosives, pigments etc

Activated Carbon

- Open up carbon structure to increase surface area available to hold (adsorb) molecules and other substances
- Heat charcoal to 1470°F (800°C) in superheated steam to remove tars from structure
- Charcoal needs to have low ash and low volatile content (no bark)

Activated carbon plant

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Current status – fast pyrolysis

- Many demo projects (inc OR and CA)
- Few commercial installations (~6 in USA producing liquid smoke)
- 10+ vendor US/Canada companies (eg, Dynamotive, Ensyn, ABRI, ROI, RFT)
- Potential mobile in-woods units – unproven
- Pricing unclear
  - $250,000+ for 1 ton/day unit
- Tampere, Finland integrated pilot facility (Metso/UPM/VTT) linked to BFB boiler

Key points

- Slow pyrolysis
  - Proven technology
  - Markets exist for product (charcoal)
- Mild pyrolysis (torrefaction)
  - Almost proven technology
  - Proven markets
  - Scale-up issues (finance, feedstock and market for product)
- Fast pyrolysis
  - Emerging technology
  - Limited markets
  - May use more energy in process than it produces
  - Cost basis unclear – need high value products or zero cost feedstock
  - Use of bio-oil as a chemical feedstock or for liquid smoke makes sense
  - Larger scale integrated systems (eg with power plant) may work
- Carry out due diligence

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Questions?

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