

Biomass to Biochar and Fast Pyrolysis Oil Fractions

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Avello Bioenergy, Inc.
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Illinois Sustainable Technology Center
Biochar: Production, Properties, & Agricultural Use

Introduction: Avello

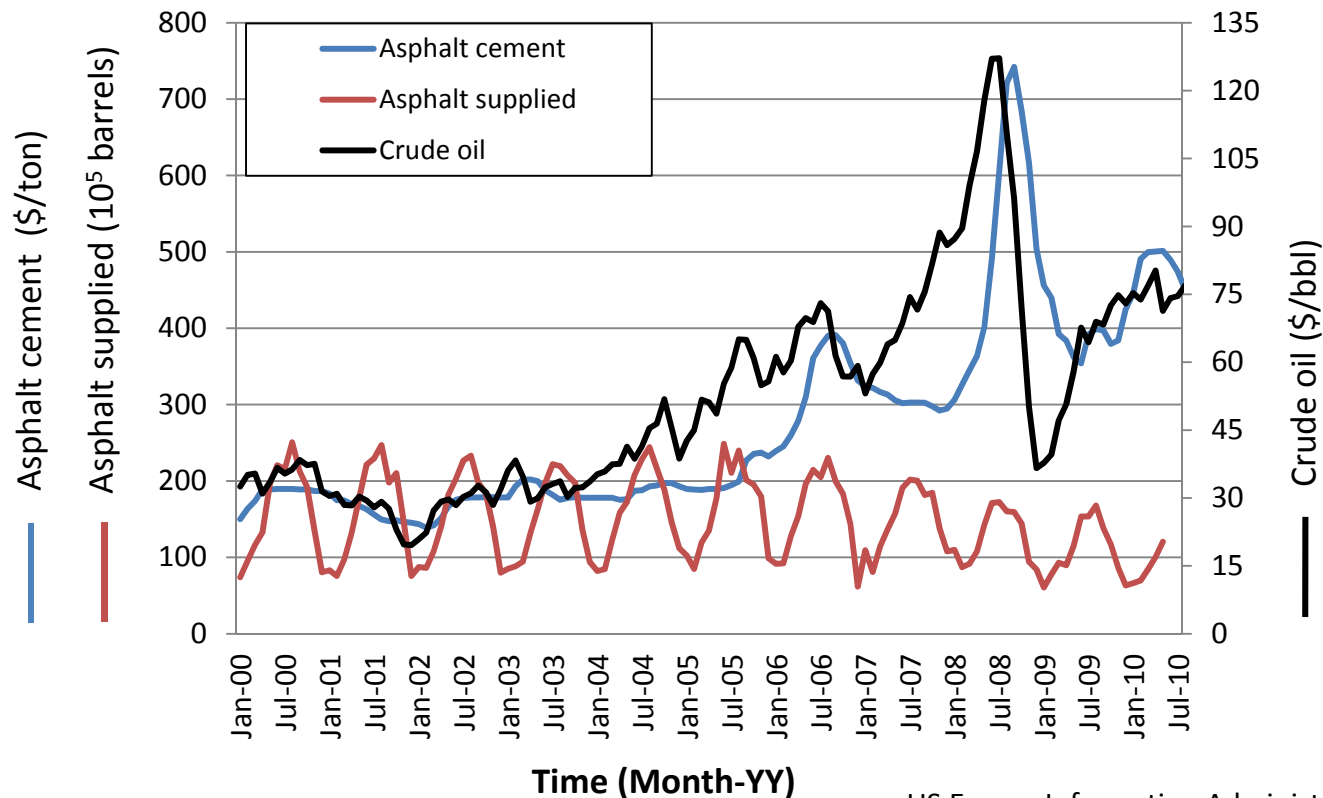
- **Avello® Bioenergy, Inc.**
 - A start-up Company formed to provide renewable and profitable feedstocks for asphalt, fuel, chemical and soil amendment products through low cost thermal conversion of biomass.
- **History**
 - Spin out of Iowa State University fast pyrolysis technology
 - Founded by Dr. Robert C. Brown and 3 graduate students in 2009
- **Team**
 - Experienced management and advisors
- **Seed funding**
 - Iowa based VC
- **Intellectual Property**
 - Technology licensed through Iowa State University Research Foundation:
 1. Pyrolysis oil fractionation
 2. Bioasphalt® technology

Challenges

- National Level
 - Rising energy prices and commodity shortages
 - U.S. growing energy demand
 - Energy security
 - Climate change and GHG emission concerns
 - Rural development

Energy prices and commodity shortages

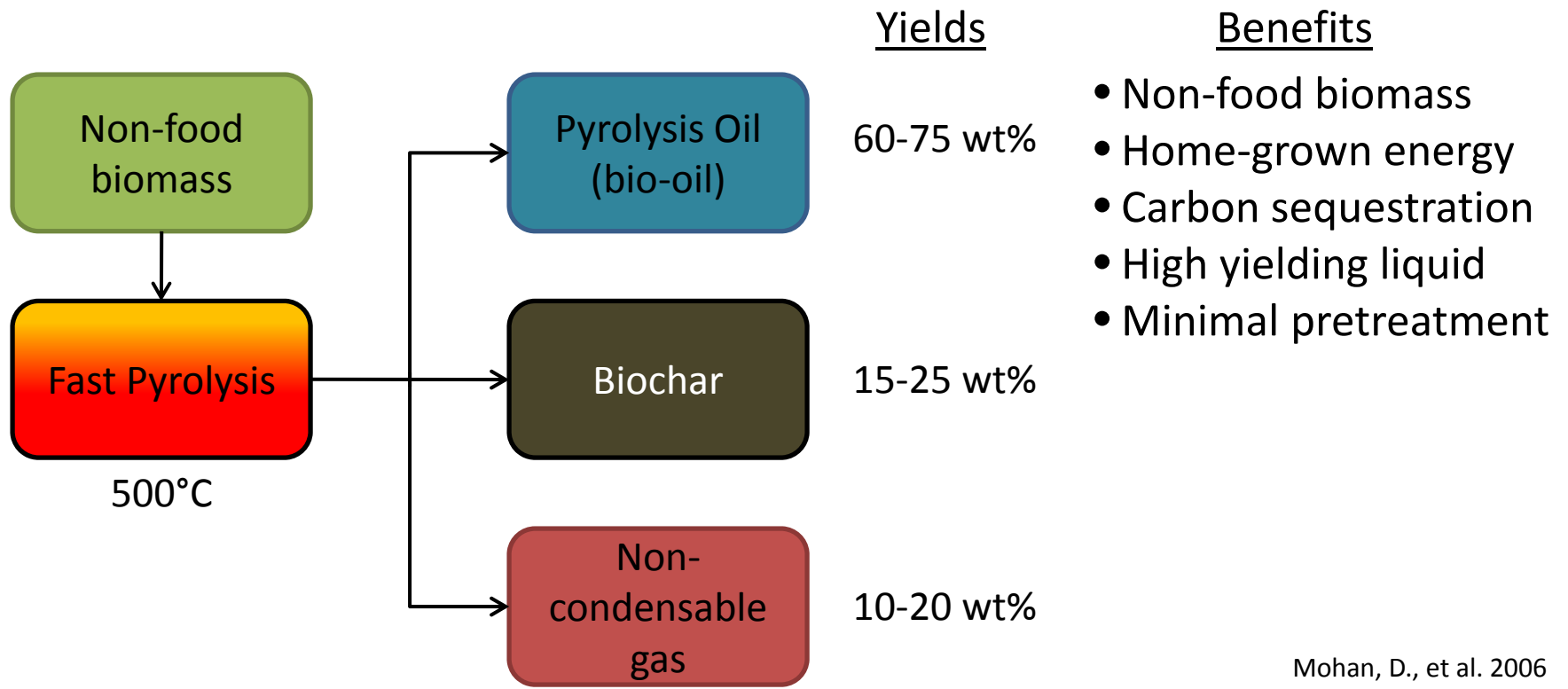
- Asphalt price mimics crude price
- Asphalt supply is diminishing



US Energy Information Administration
Tennessee Dept. of Transportation Bituminous Index

Solution

- Fast Pyrolysis
 - Rapid thermal decomposition in absence of oxygen



Mohan, D., et al. 2006
R.C. Brown, 2003

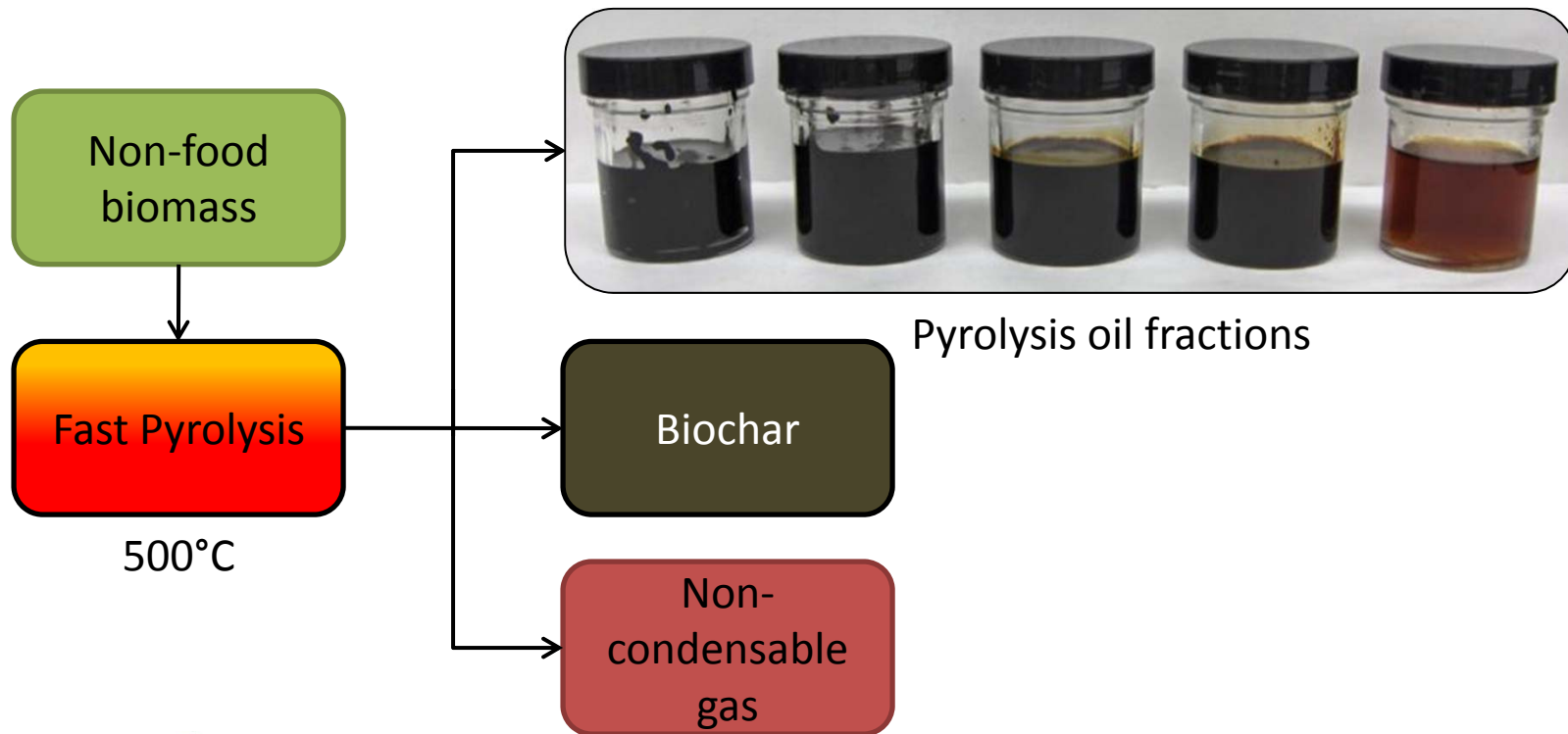
Bio-oil incompatibility

- Conventional bio-oil uses:
 - Combustion in boilers, IC engines and gas turbines for heat and power
 - Niche applications in food flavoring, preservatives, resins
- Limited applications due to poor fuel properties:
 - High water, oxygen and acidic content → low heating value and corrosion
 - Oxygenated → instability and immiscibility with hydrocarbons
 - Solids content → deposits, particulate emissions, fouling
 - Difficult to upgrade → expensive transportation fuels

Chiaromonti, D., et al. 2007
Oasmaa, A., et al. 2005

Avello Solution

- Biomass fast pyrolysis with bio-oil fractionation technology
 - Removes water and acidic compounds → improves stability and HHV
 - Unique bio-oil properties for novel applications



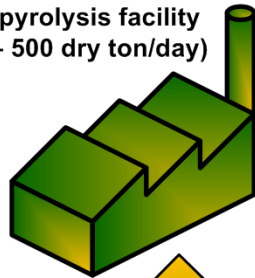
Product line

- Bioasphalt®
 - Direct replacement for petroleum derived binders
 - Lower process paving temperature = reduced costs
 - Pavement and roofing applications
- Biofuel Oil™
 - Improved properties over traditional pyrolysis oil
 - Liquid fuel for heat and power generation
 - Heavy fuel oil applications
- Biochar
 - Soil amendment and carbon sequestration applications
 - Porous structure helps to retain water and nutrients
 - Organic carbon and nutrients = increased soil fertility

Markets

Fast pyrolysis facility
(250 – 500 dry ton/day)

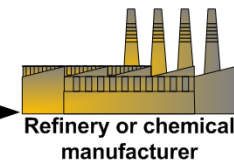
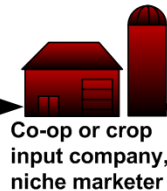
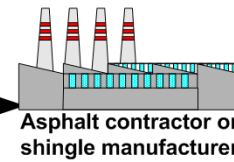
Biomass
Agricultural or
wood residues



PRODUCTS



CUSTOMERS



END-USES

Asphalt paving

Asphalt roofing

Renewable power

Renewable heating
(Residential and commercial)

Renewable Marine fuel

Soil amendment

Advanced biofuels

Specialty products (resins, adhesives, flavor and fragrance)

- Product flexible
- Regionally sized facilities
- Short transportation distance

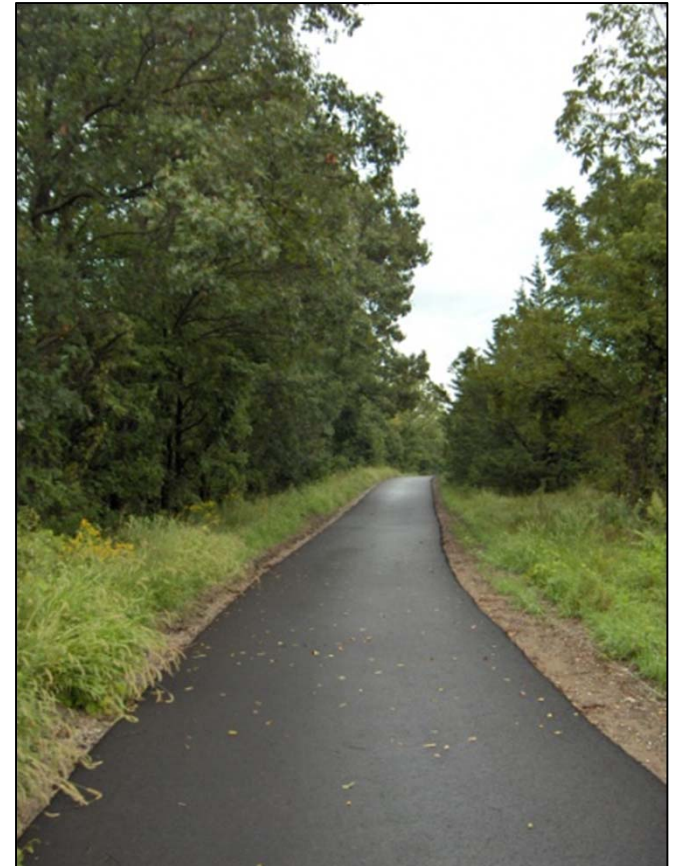
Proof of Concept

- 6 kg/hr reactor system at ISU
 - 6 inch fluidized bed
 - Equipped with proprietary fractionation technology
- Continuous 5-24 hr/day campaigns
 - Red oak biomass feedstock
 - Over 100 gallons of bio-oil
 - 125 kg of biochar



Product Development

- Bioasphalt®
 - Meets or exceeds asphalt standards in lab
 - Iowa DOT Bike Path Test near Des Moines
 - Fall 2010
- Biofuel Oil™
 - Combustion tests planned



September 2010

Product Development

- Biochar
 - Hot biochar is highly reactive
 - Exposure to air may lead to combustion
 - Investigating methods to safely store, handle and formulate biochar for distribution and land application

- Potential applications include:
 - Soil amendment
 - Carbon sequestration
 - Renewable fuel



Economics

- Proforma economics are robust for commercial plants
- Biochar requires value of pyrolysis oil to make economics work
- Biochar is a co-product to pyrolysis oil products
 - Biochar pricing is challenging
 - Energy basis: assume 25 MJ/kg and coal price \$1.95/MMBTU = \$42/ton
 - Agronomic benefits and carbon sequestration may increase the price

Business Plans

- Scale-up technology to 2.5 TPD Demonstration Plant
- Align with strategic partners
 - Asphalt and fuel-oil industries, industrial power generators, farming co-ops and feedstock suppliers
- Build, own and operate with strategic licensing and joint ventures

Conclusion

- Fast pyrolysis is one solution to challenges
 - *Home-grown, non-food* feedstocks
 - *Renewable* energy source for heat, power and fuels
 - Potential for long term *carbon sequestration*
 - Economic development for rural and agricultural regions
- Pyrolysis oil fractionation technology opens new markets
- Biochar is a co-product to pyrolysis oil; need both for economic viability

Thank you.

Questions?

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Abstract

Fractionated fast pyrolysis oil properties are superior to conventional bio-oil properties since water and acidic compounds are largely concentrated in a single fraction. This improves the energy content, stability and utility of the remaining fractions while providing new opportunities for pyrolysis oil end-uses. A proprietary fractionation technology enables production of novel and customized pyrolysis liquid products including: Bioasphalt® for paving and roofing applications, Biofuel Oil™ for renewable heat and power generation, and chemical feedstocks for specialty applications. Biochar is a high carbon content, solid co-product from the process. Avello is evaluating both niche specialty applications and large scale agricultural and carbon sequestration markets for biochar. Fast pyrolysis can produce a biochar which is highly reactive and combustible. Avello is investigating methods to safely handle and process biochar for formulation and distribution. Avello Bioenergy is an early stage, venture-funded, Iowa-based Company commercializing proprietary technologies licensed from Iowa State University. Avello Bioenergy provides renewable and profitable feedstocks for asphalt, fuel, chemical and soil amendment products through low cost thermal conversion of biomass.