New Bio-refinery Concept to Convert Softwood Bark to Transportation Fuels

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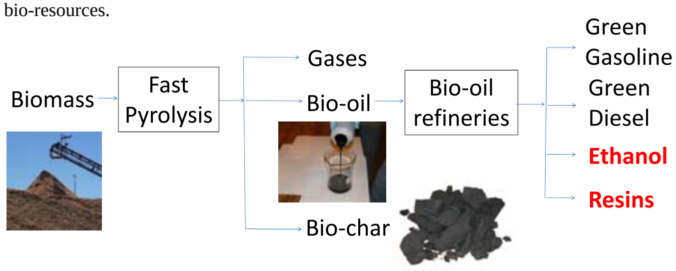
INTRODUCTION

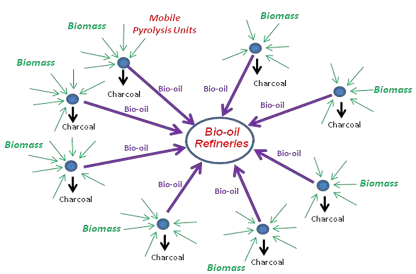
The Washington State biomass inventory shows that there is over 16.9 million tons of underutilized dry biomass available annually of which 84.2 % is woody biomass. Mill residues composed of residue/bark represent 30.8 % (5.2 million tons/year).

Pyrolysis is one of the leading technologies considered for densification since it can convert between 60 and 75 mass % of the original biomass into a crude bio-oil. Bio-oil can be economically transported to bio-refineries located up to 500 km from the bio-resources.



NEW CONCEPT OF BIOMASS ECONOMY PROPOSED: (1) Distributed pyrolysis units close to biomass resources, to produce crude bio-oils and chars, and (2) Refineries to further convert these oils into transportation fuels and chemicals.

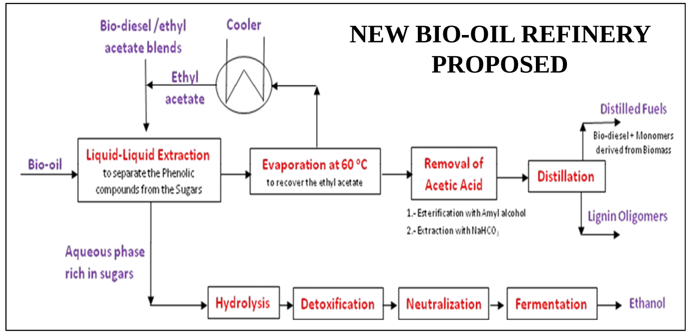
The feasibility of building mobile vs. stationary pyrolysis units and centralized refineries vs. distributed rural refineries with the depend of: (1) the costs associated to operate mobile pyrolysis units, (2) the costs of transportation and savings associated with (3) the economies of scale



PROBLEM ADDRESSED

BIO-OIL REFINERY CONCEPT STUDIED BY PNNL, UOP AND DYNAMOTIVE: The two step bio-oil hydro-treatment refinery is able to convert between 35 and 40 mass % of the bio-oil into green gasoline and green diesel. Thus the pyrolysis - bio-refinery concept proposed is able to convert between **21 and 28 %** of the biomass into fungible hydrocarbons (Green Gasoline and Green diesel) at **$2.04/gal**.

NEW BIO-OIL REFINERY CONCEPT PROPOSED: Although the two step hydrotreatment of bio-oil to produce green gasoline and green diesel is a very promising concept to convert the phenolic and furanic compounds into hydrocarbons. There are several reports suggesting that the conversion of pyrolytic sugars to hydrocarbons is low and that are in fact the sugars are responsible for coke formation and rapid desactivation of hydrotreatment catalysts. Separating and fermenting the pyrolytic sugars could be a better approach. A new bio-refinery concept based on this idea is proposed.

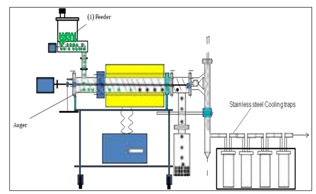


OBJECTIVES

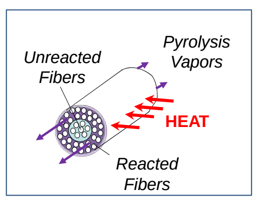
1.- To build new laboratories at Washington State University to produce bio-oil from softwood bark and to analyze and refine the resulting oils.
2.- To determine the yield of bio-oil, charcoal and gases resulting from the pyrolysis of Softwood bark in different pyrolysis reactors.
3.- To evaluate the extraction of bio-oils with bio-diesel/ethyl acetate blends and to quantify the distribution coefficients of selected chemical species.
4.- To separate mono-phenols from the bio-diesel rich phase via distillation and to analyze the resulting fractions.
5.- To develop a new scheme to produce ethanol from pyrolytic sugars.

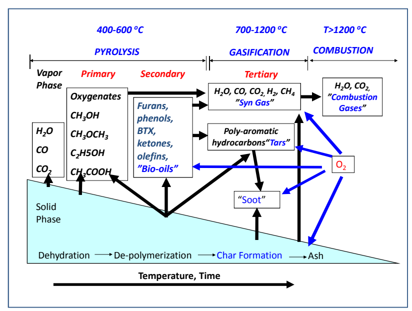
RESULTS

NEW LABORATORIES BUILT AT WSU



BIOMASS THERMOCHEMICAL REACTIONS

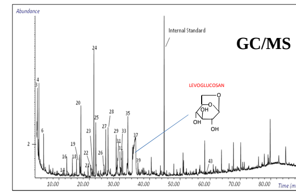




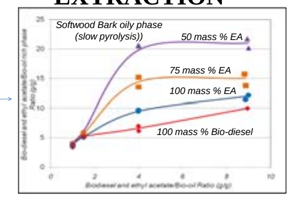
YIELD OF PRODUCTS FROM SOFTWOOD BARK

	Batch reactor	Auger Pyrolysis	Auger Pyrolysis	Auger Pyrolysis	Bubbling Fluidized bed
Liquid	45	36	32	38	51
Charcoal	40	27	24	22	32
Gases	15	37	44	39	17

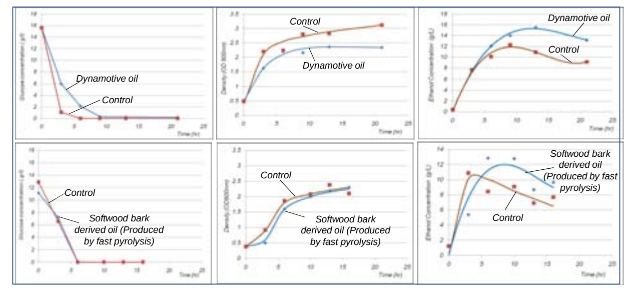
BIO-OIL CHARACTERIZATION



LIQUID-LIQUID EXTRACTION



FERMENTATION OF PYROLYTIC SUGARS



CONCLUSIONS

1.- Although the chemical composition of softwood bark is not ideal (high contents of lignin and extractives) for the production ethanol the conversion of these materials to transportation fuels and chemicals is technically viable.
2.- As expected, among the technologies studied in this project, fast pyrolysis resulted in the highest yield of bio-oils.
3.- The extractions of bio-oils with ethyl acetate/bio-diesel blends is a viable approach to obtain an organic fraction rich in phenols and an aqueous phase rich in sugars.
4.- Although the idea of converting pyrolytic sugars to ethanol was proposed a while ago by other investigators, this is the first time that the technical feasibility of this concept has been proven experimentally. We can confirm that it is possible to convert the pyrolytic sugars from bio-oils into ethanol.

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Reference:

Garcia-Perez M, Chen S, Zhou S, Wang Z, Lian J, Johnson RL, Liaw S-S, Das O: New Biorefinery Concept to Convert Softwood Bark to Transportation Fuels. Final Report to the Washington State Department of Ecology. Interagency Agreement (No. C0800247) (June 1st, 2009).