

Generating Bioethanol from Biomass Forest Residues and Primary Sludge

Kristina Knutson and A.J. Ragauskas

OBJECTIVE

Bioethanol can be produced from any cellulosic fibers. One viable bioethanol resource is unmerchantable timber left behind after harvesting trees for lumber paper-making. This material includes branches, twigs, and pine needles. Another potential fiber source is primary sludge from paper mills. Fibers too small to be retained could be converted into fuel ethanol.

These studies examine the feasibility of converting these untapped fiber resources into ethanol.



Branches and Twigs
Twigs <1cm in diameter

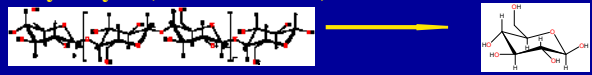
PROJECT DELIVERABLES

- Characterization of untreated, pretreated and enzyme-hydrolyzed biomass solids
 - Ash and extractives
 - Acid soluble and Klason lignin content
 - Carbohydrate profile
- Characterization of pretreatment filtrate and enzyme hydrolyzed solutions
 - Glucose and Cellobiose
 - Fermentation Inhibitors
- Efficacy of Enzyme Hydrolysis
 - Time course measurements of glucose release
- Yield of Ethanol Fermentation
 - Time course measurements of glucose release

Sample	Pretreatment	Ash	Extractives	Acid-Insoluble Lignin
Pine Needles	Untreated	2.55%	24.57%	40.59%
	Stage 1	0.16%	31.04%	
	Stage 2	2.70%	37.32%	
Pine Twigs	Untreated	1.35%	13.15%	38.16%
	Stage 1	2.74%	11.86%	
	Stage 2	3.34%	29.18%	
Pine Branches	Untreated	0.37%	18.32%	34.58%
	Stage 1	1.85%	9.78%	
	Stage 2	0.78%	16.66%	
Pine Bark	Untreated	0.83%	3.20%	51.78%
	Stage 1	3.11%	8.52%	
	Stage 2	2.00%	14.16%	

PROJECT BACKGROUND

Hydrolysis (saccharification) of cellulose



Cellulose must be hydrolyzed to release glucose

Fermentation to produce bioethanol

Yeast are added to the hydrolyzed solution

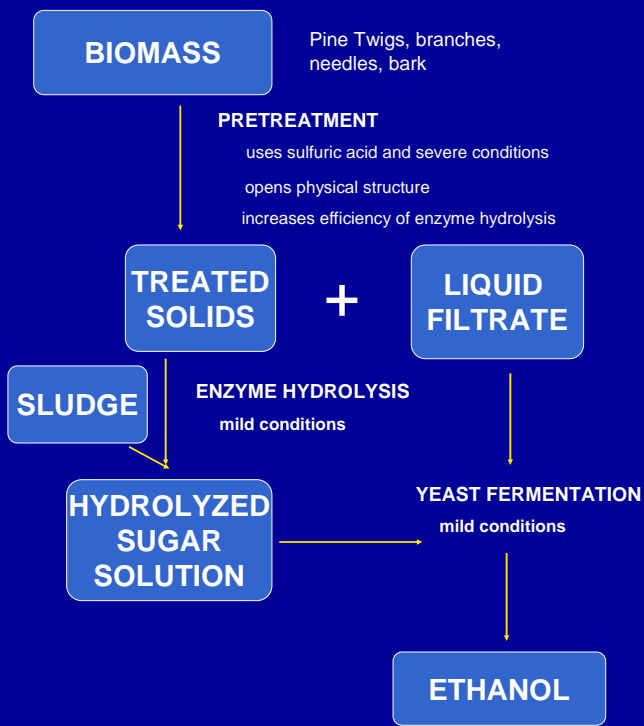


Process Concern

Need to minimize production of fermentation inhibitors such as furfural and 5-hydroxymethylfurfural often produced by hydrolysis of hemicellulose



PROCESS OVERVIEW

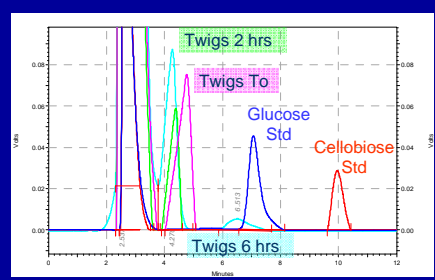


OPPORTUNITY

- U.S. ethanol production is expected to grow from 4.25 billion gallons/yr (16 billion L/yr) in 2005 to 7.5 billion gallons/yr (28.39 L/yr) by 2013.
- The renewable fuel standard (RFS, U.S. Energy Bill, August, 2005) will guarantee a market for the increasing ethanol volume directed to the fuel markets by virtue of mandating 10 % ethanol in all U.S. gasoline by 2013.



Air dried sludge from linerboard mills
Left Rome GA, Middle Pine Hill AL, Right Springfield OR



HPLC Data
Enzyme Hydrolysis
Pine Twigs
Shows free glucose after 6 hrs of enzyme hydrolysis, but not at time zero or at 2 hrs

Sludge Samples	Springfield	Pine Hill	Rome
Percent fines:			
Arithmetic	25.52%	33.41%	32.46%
Length weighted	3.05%	4.91%	4.30%
Mean length:			
Arithmetic	0.593±0.029mm	0.487±0.024mm	0.542±0.026mm
Length weighted	2.437mm	2.029mm	2.152mm
Weight weighted	4.212mm	3.274mm	3.418mm
Length weighted	0.122	0.091	0.079
After centrifugation to thicken			
% Ash	6.70%	5.81%	7.74%
% Extractives	5.73%	6.14%	8.89%
% Acid-Insoluble Lignin	26.53%	40.72%	45.06%