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CONN CENTER FOR RENEWABLE ENERGY RESEARCH

ADVANCES IN CO-PRODUCT FIBER UTILIZATION FOR NEW PRODUCTS & INCREASED VALUE

Jagannadh Satyavolu

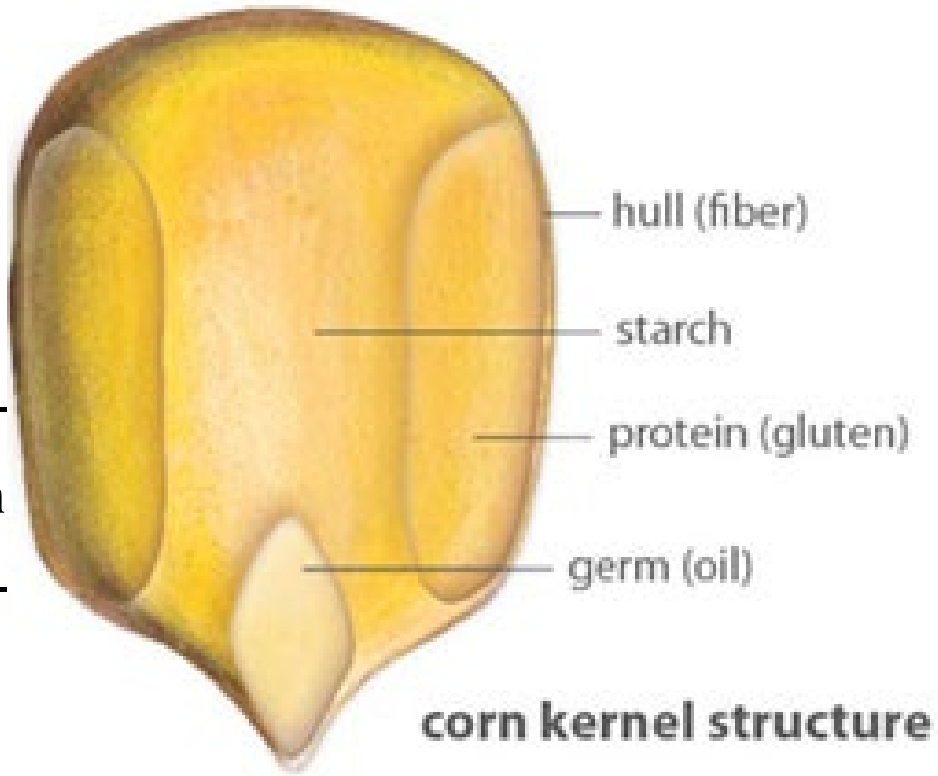
Theme Leader

Biomass Conversion and Biofuels

Corn Fiber

Corn pericarp fibers are rich in hemicellulose

Composition	Corn Fiber from Kernels
hemicellulose	39-40
% cellulose	11-13
% lignin	3-6
% ash	<1



A commercial source for corn fiber is *Dried Distillers Grains* (DDG)

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DDG Composition

	Original DDG
Crude Protein (wt %)	25.72
Crude Fat (wt %)	10.48
Ash (wt %)	1.76
Neutral Detergent Fiber (wt %)[a]	**53.51**
Acid Detergent Fiber (wt %)[b]	27.76
Total Carbohydrates (wt %)	62.04
Hemicellulose (wt %)	25.75

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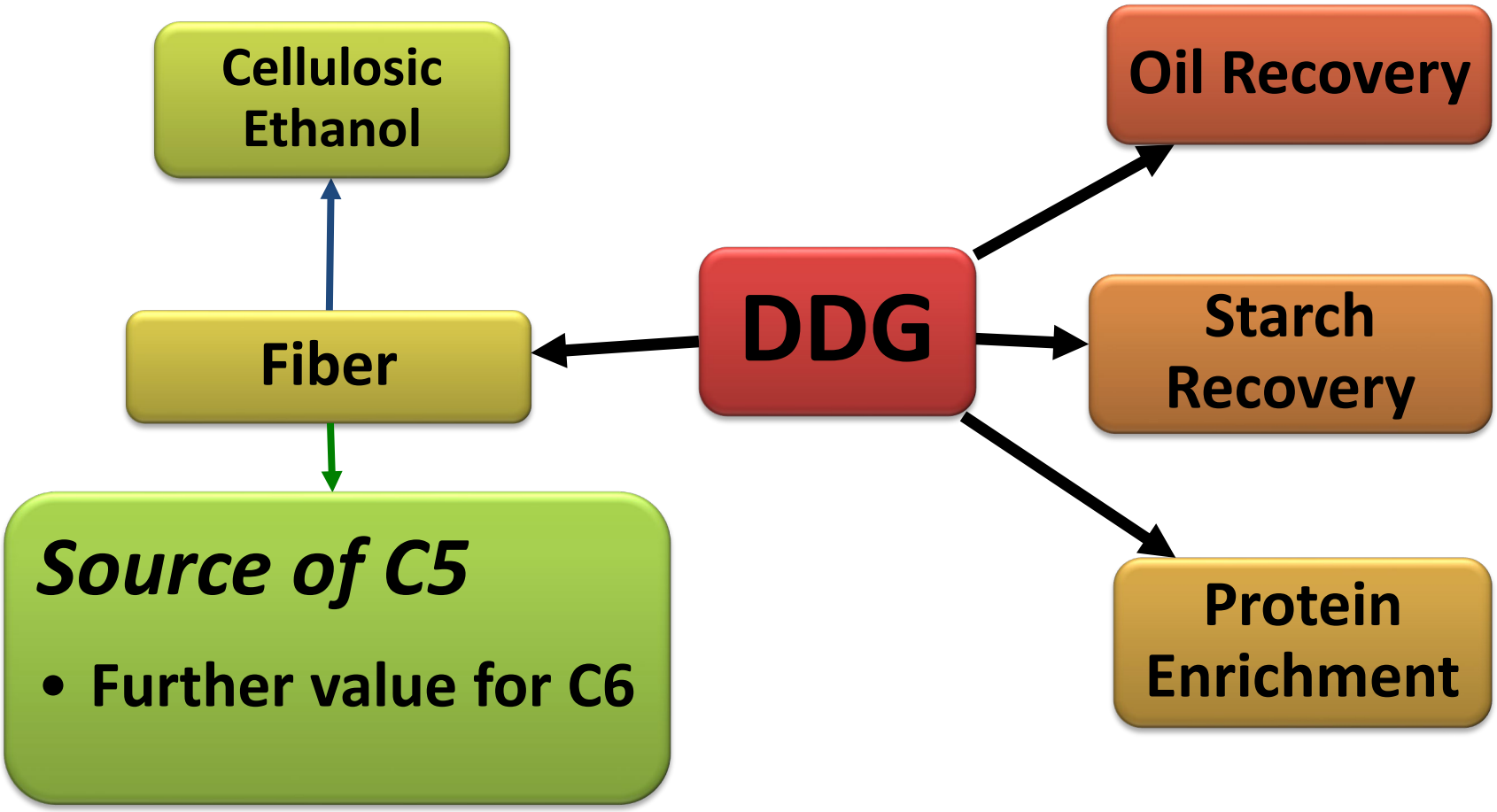
Value Enhancement Strategies



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DDG Processing for fiber

Screening

1

Feed Applications

Selective Hydrolysis

2

Feed and/or other High Value Applications

3

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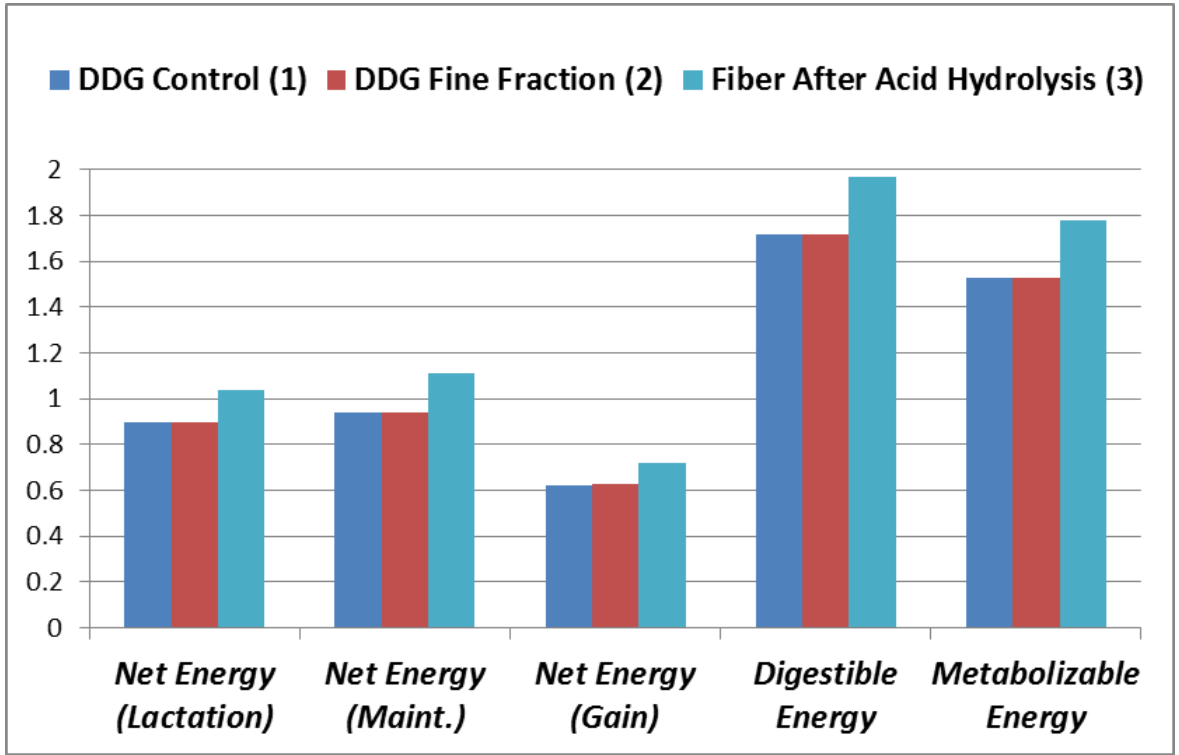
Residual Fiber after Hydrolysis

OPPORTUNITY # 1

Compared to DDG (control),

- *the fines fraction has*
  - *11% more protein*
  - *36% more total lysine*
- *the fiber after acid hydrolysis has*
  - *113% higher crude fat*
  - *15% higher total digestible nutrients, and*
  - *15% higher digestible energy*
  - *69% less total lysine*



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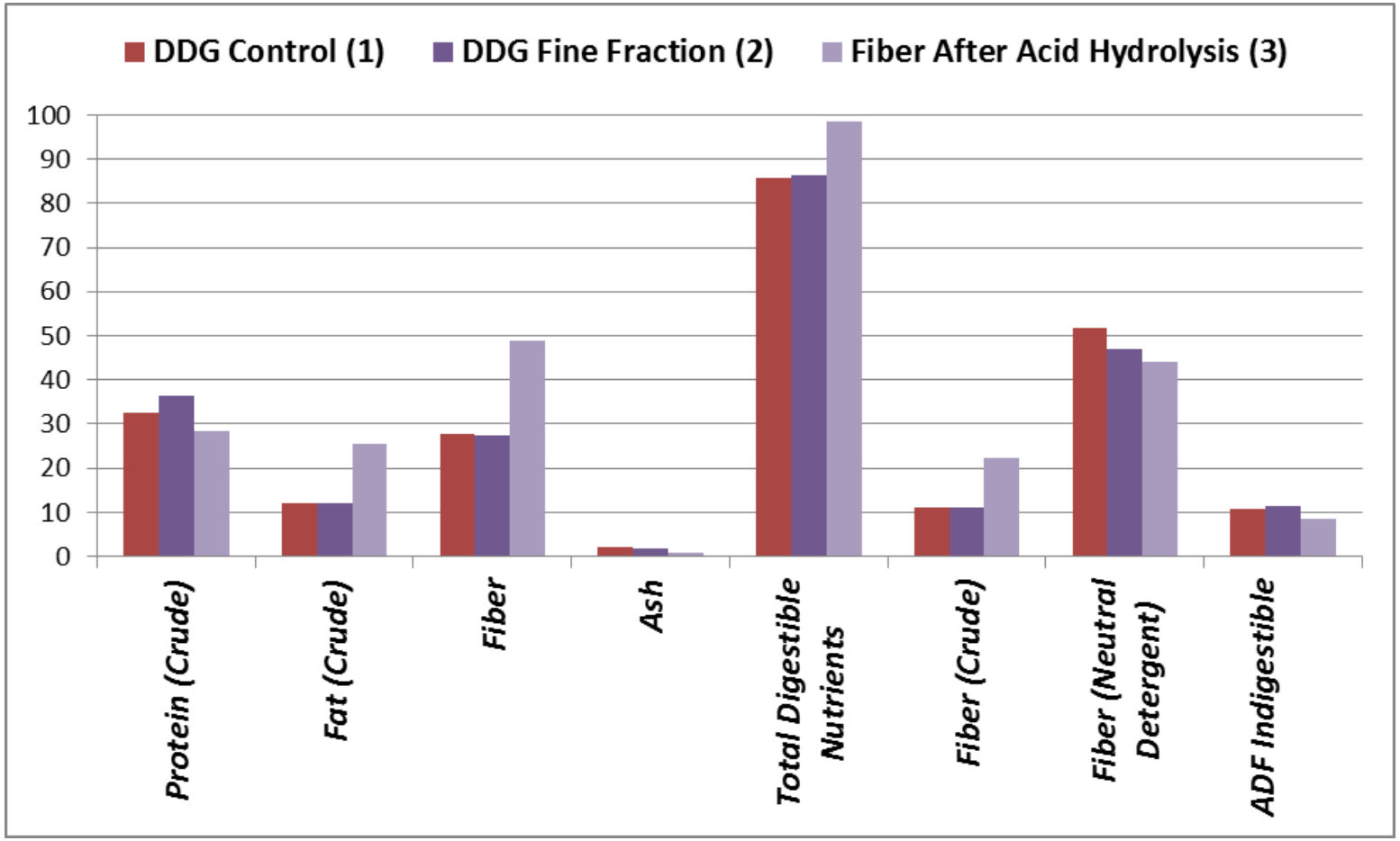
Residual Fiber after Hydrolysis

OPPORTUNITY # 1



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Three value added products from DDG:

- Protein rich feed (1)
- Energy rich feed (2)
- C-5 hydrolyzate (3) Source of Xylose

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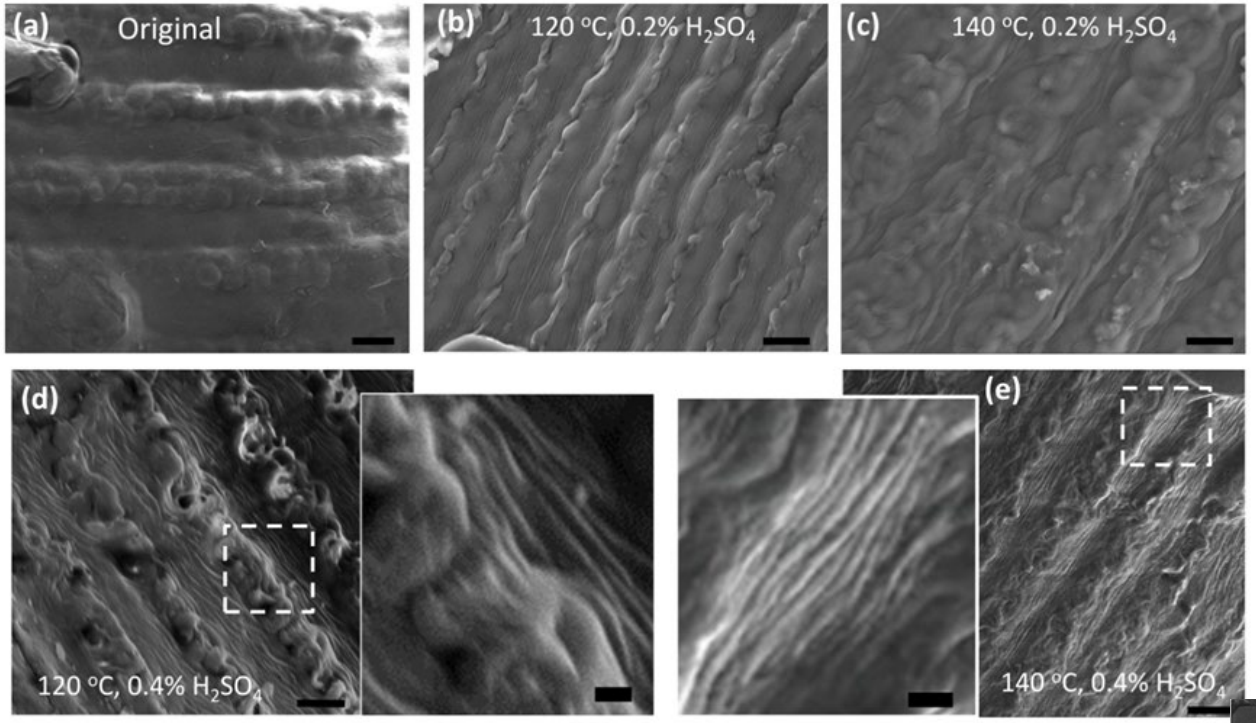
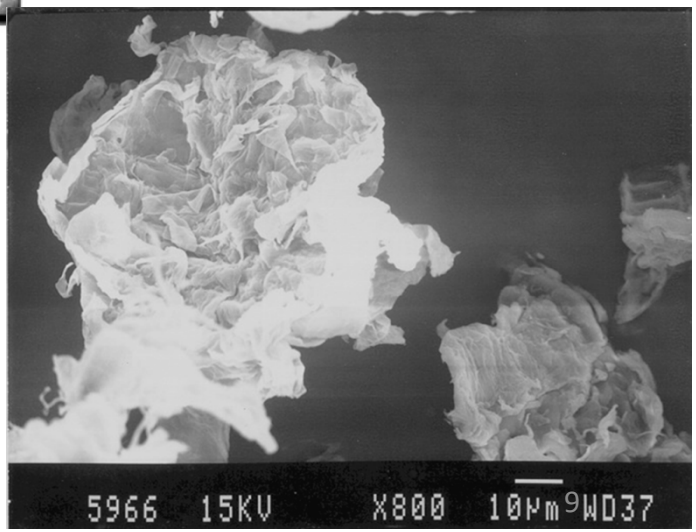
Residual Fiber after Selective Hydrolysis





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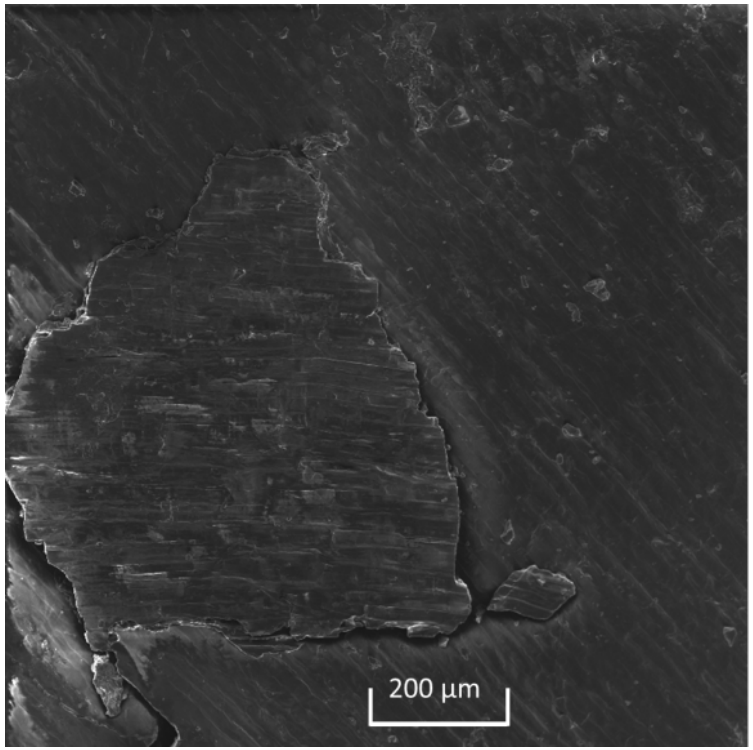
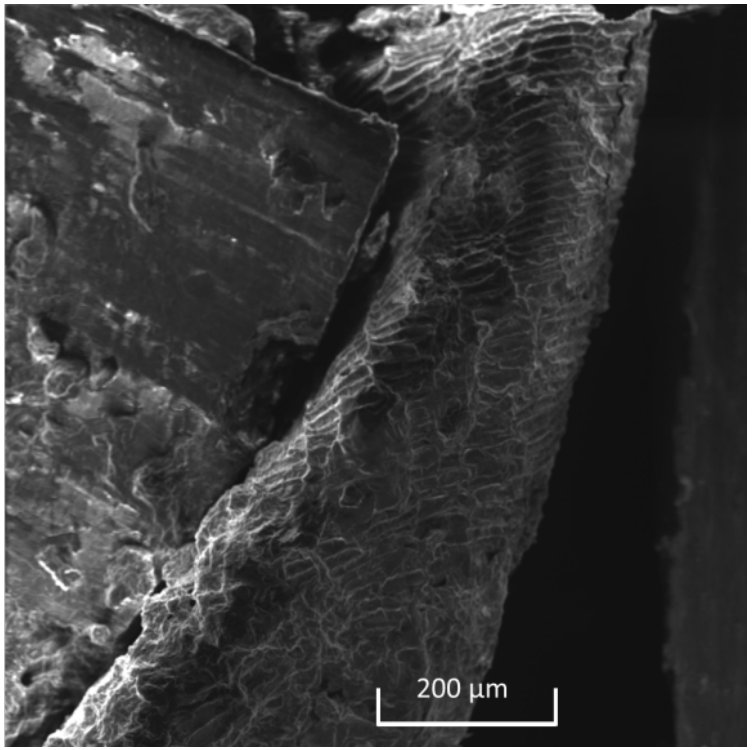
SEM-
Corn Fiber Surface

(a)





(b)

SEM images showing differences in surface structure between pre and post-hydrolysis DDG fibers (a), (b)

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Activated Carbons from Corn Fiber

OPPORTUNITY # 2

Sample (1:1 KOH to Grains)	BET Surface Area (m^2/g)	Langmuir SA (m^2/g)	External Surface Area (m^2/g)	Average Pore Width (nm)
DDG: Pre-Hydrolysis	10.44	15.47	7.35	9.533
DDG: Post-Hydrolysis	1705.58	2440.36	1245.13	2.922
Control: MWV	1226.71	1751.39	797.18	3.620

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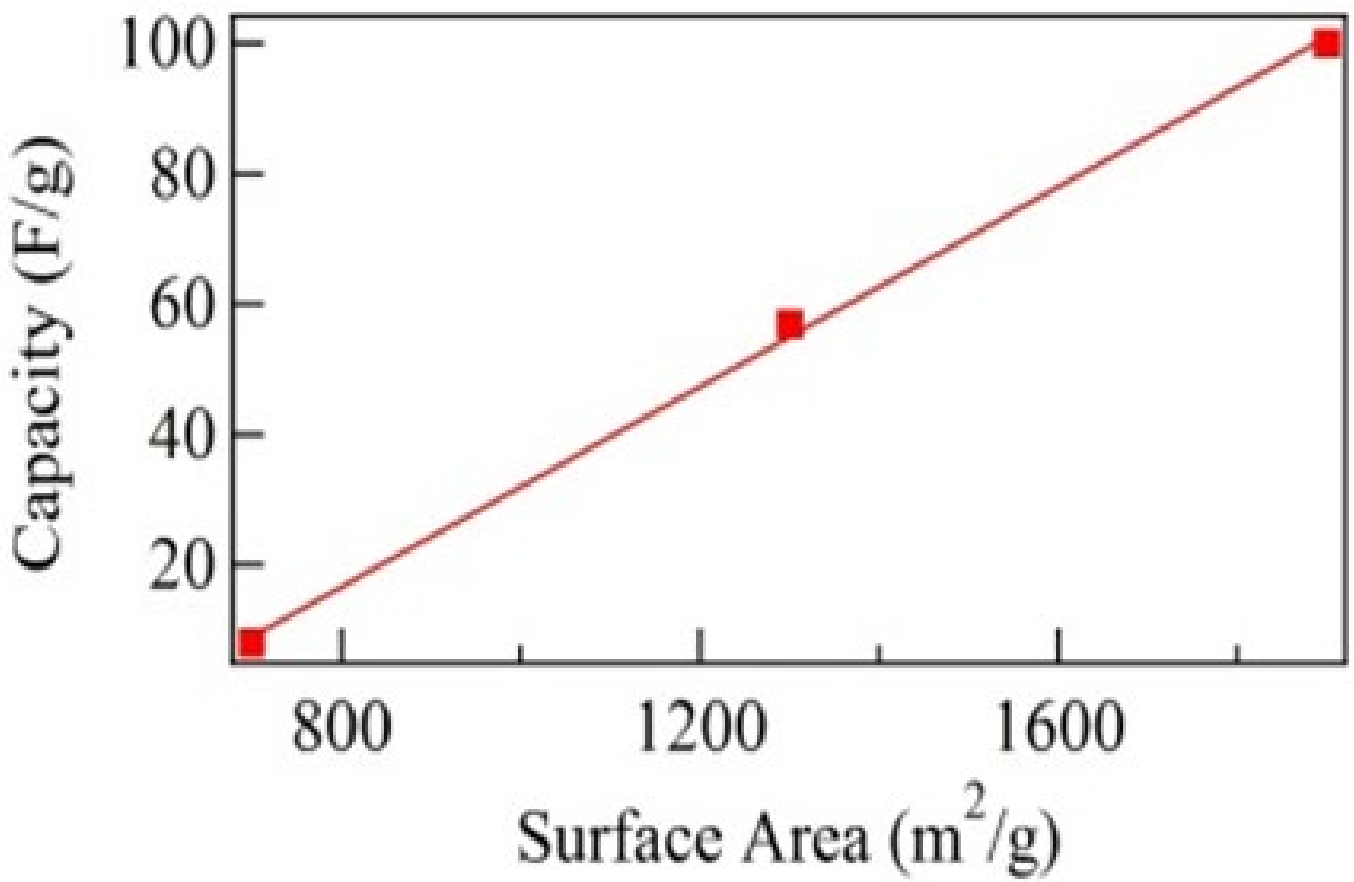
Electrochemical performance Co-Product ACF

OPPORTUNITY #2



measured in a 2032 coin-cell configuration system using 1.5 M TEAPF6-PC (Tetraethylammonium hexafluorophosphate in propylene carbonate) solution as the electrolyte

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Residual Fiber after Hydrolysis: Co-Product: ACF

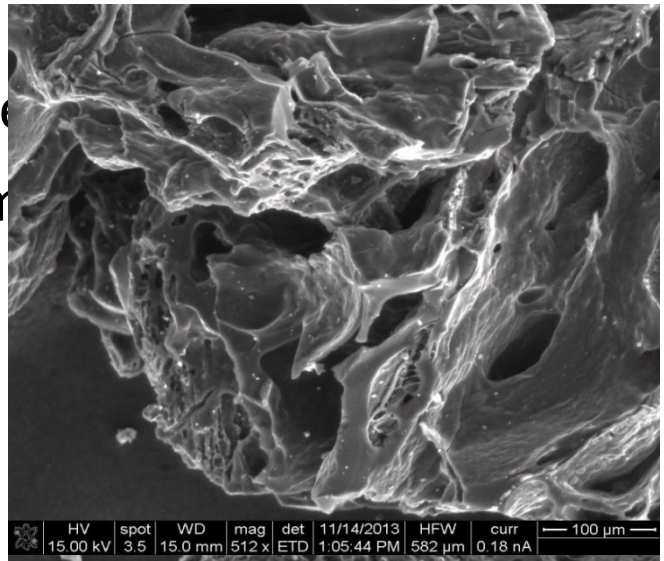
OPPORTUNITY # 2

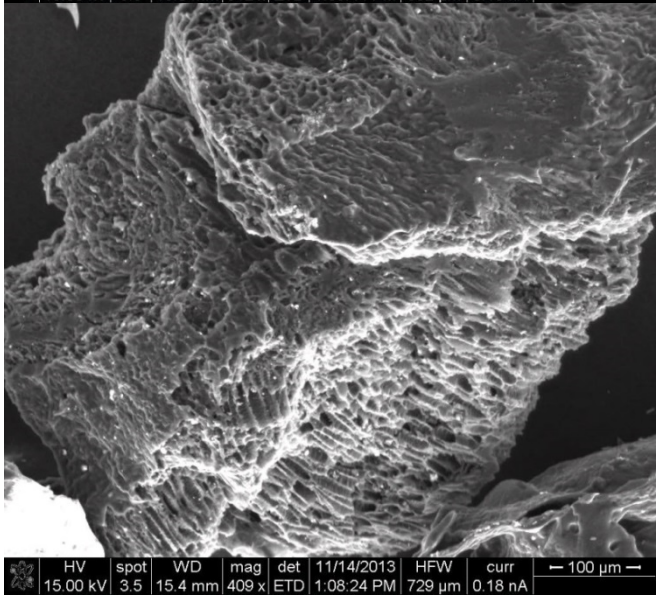
Carbonization and activation proce

- BET Surface Area: 1300-1600 m
- Pore Volume: 0.94 cm^3/g

Energy Storage applications

- Li-Ion batteries
- Supercapacitors
- PV cells
- Hydrogen storage





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- C-5 hydrolyzate (3) — Source of Xylose

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About Xylose

OPPORTUNITY # 3

- a natural and zero calorie sugar.
- rapidly absorbed from the small intestine and not metabolized in the liver.
- a safe sugar - is used routinely in medical tests in the proximal small intestine.
- may help prevent progression of obesity-related metabolic disorders by improving lipid oxidation.
- also a sucrose inhibitor suggested to suppress development of obesity-related diseases
- Commercially available at xylitol – a modified sugar alcohol

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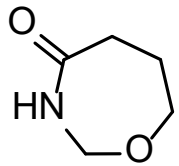
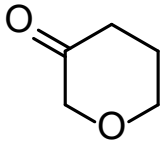
C5 Platform of Products

BIOMASS

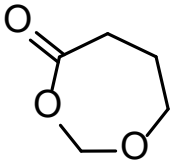
DDG
Kenaf
Bagasse
Soy Hulls



Lactam

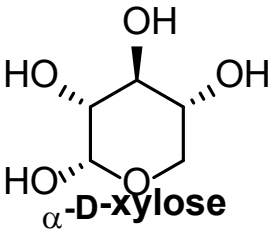


3-THP



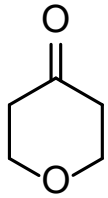
Lactone

Applications
biodegradable polymers



α-D-xylose

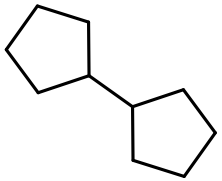
Applications
sweeteners
(xylitol)
food coloring



4-THP

Cyclopentadiene

Applications
norbornene / cyclic olefin copolymers (COC)



Bicyclopentane

Applications
aviation fuel

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Xylose Isolation Technology

OPPORTUNITY # 3

Technology Highlights

- Xylose isolated as a solid sugar
- conducted under ambient conditions
- Uses cost effective green solvents and reagents
- Regenerate reagent and solvents
- Smaller foot print plant, low capital

"Isolation of C5-Sugars from the Hemicellulose-Rich Hydrolyzate of Distillers Dried Grains" *ACS Sustainable Chem. Eng.* **2015**, *3*, 2452-2457

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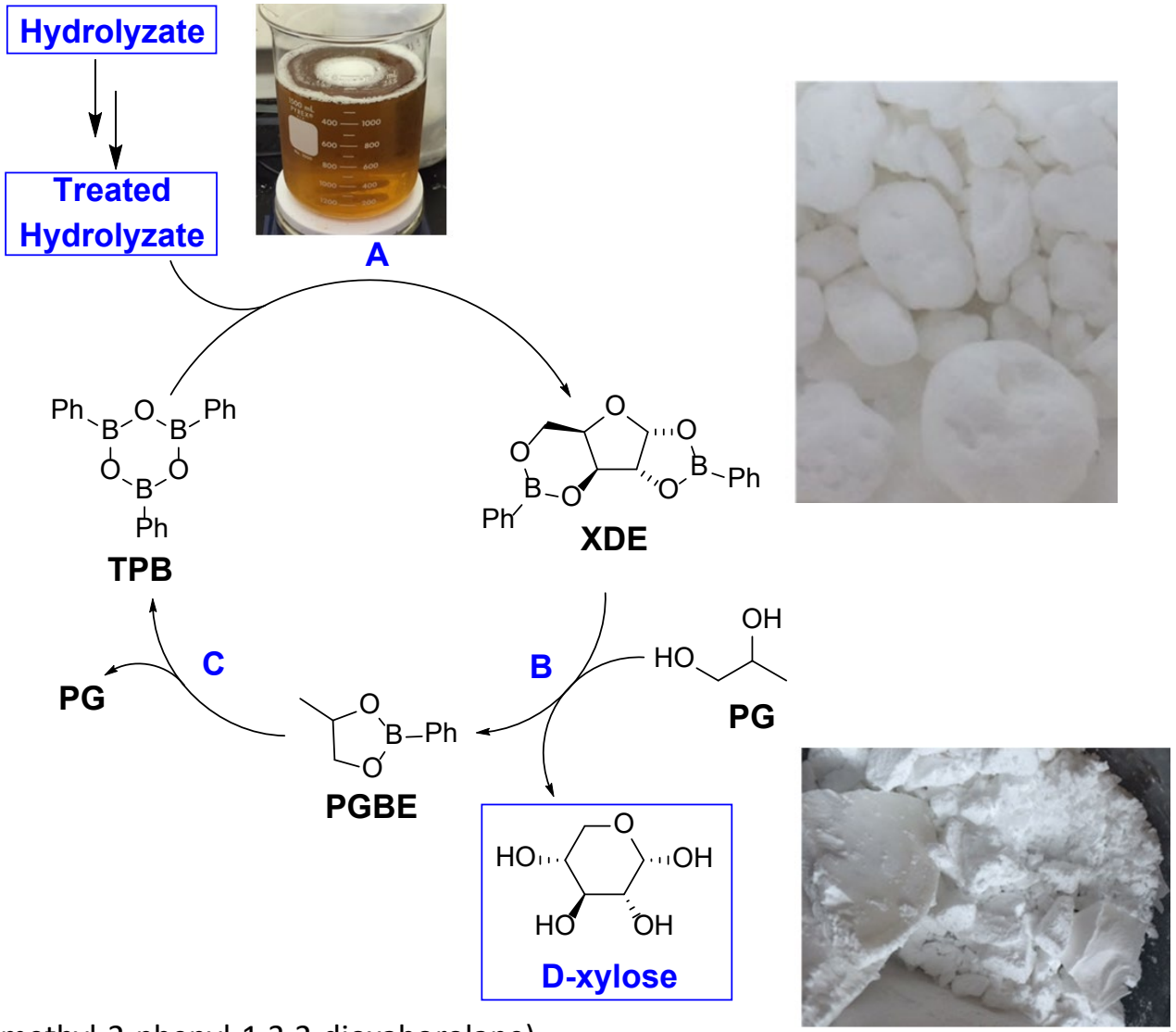
Xylose Isolation Cycle

OPPORTUNITY # 3



PGBE = propylene glycol ester; (4-methyl-2-phenyl-1,3,2-dioxaborolane)

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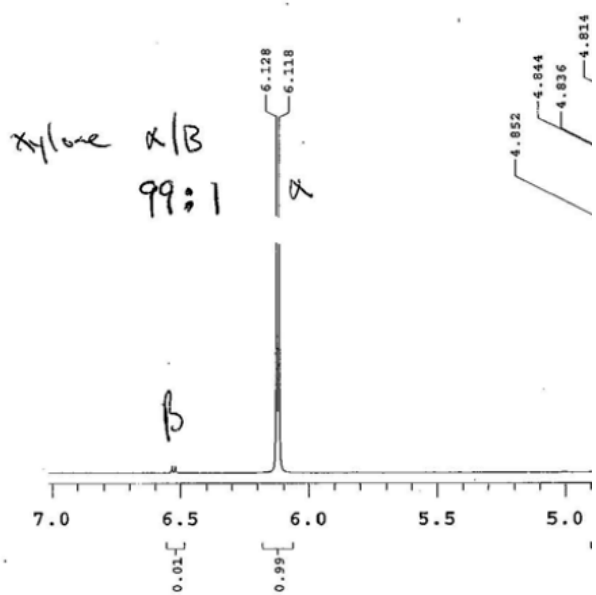
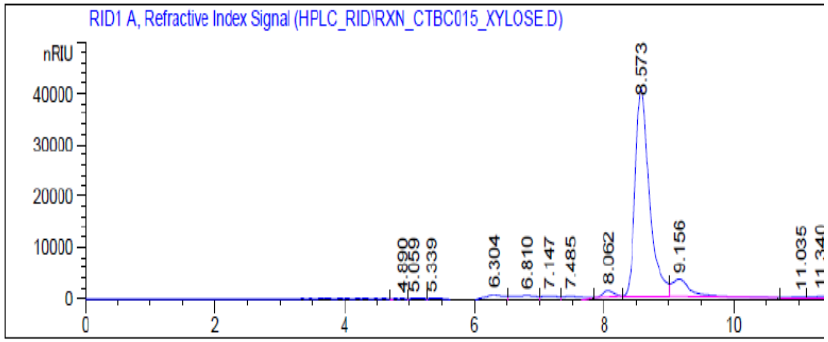
Quality of Isolated Xylose

OPPORTUNITY # 3



NMR analysis of isolated Xylose



HPLC of the Isolated xylose

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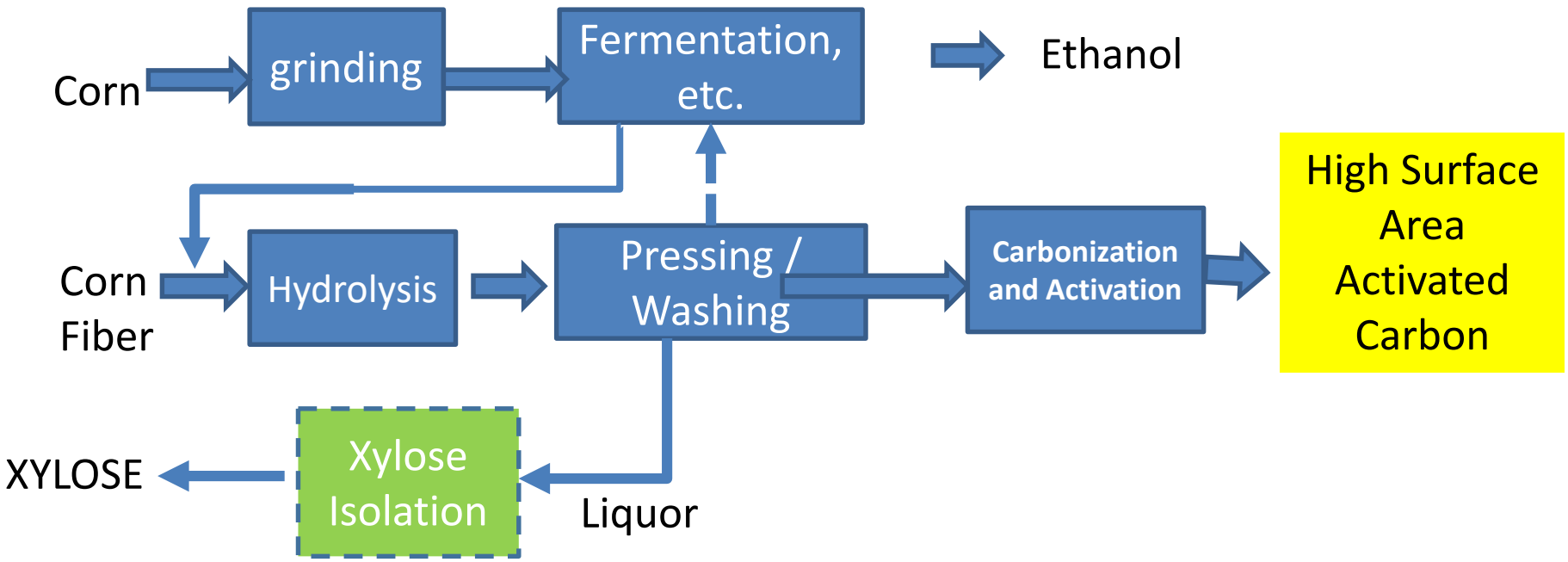
Proposed Process Flow Sheet for an ethanol plant



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Value Creation

Basis:	**100,000**	bushels per day corn grind
Fiber Yield	4.5	lb per bushel
Available fiber	450,000	lb per day
Assigned value for fiber	$0.08	per lb

Xylose Content:	20%	on fiber

	Current	Proposed
as feed	$36,000.00	$ (36,000.00)
as xylose		$ 122,727.00
as high surface area carbons		$ 36,000.00
TOTAL	$36,000.00	**$ 122,727.00**

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Thank you