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Micronized Wood Milling for Biofuels and Biochemical Production

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MILLED WOOD COLLABORATORS

Brief Review of Forest Residuals to Alternative Jet Fuel

Background of Feedstock Sourcing and Depot Strategies

Pros & Cons of Mechanical Strategies in Depots

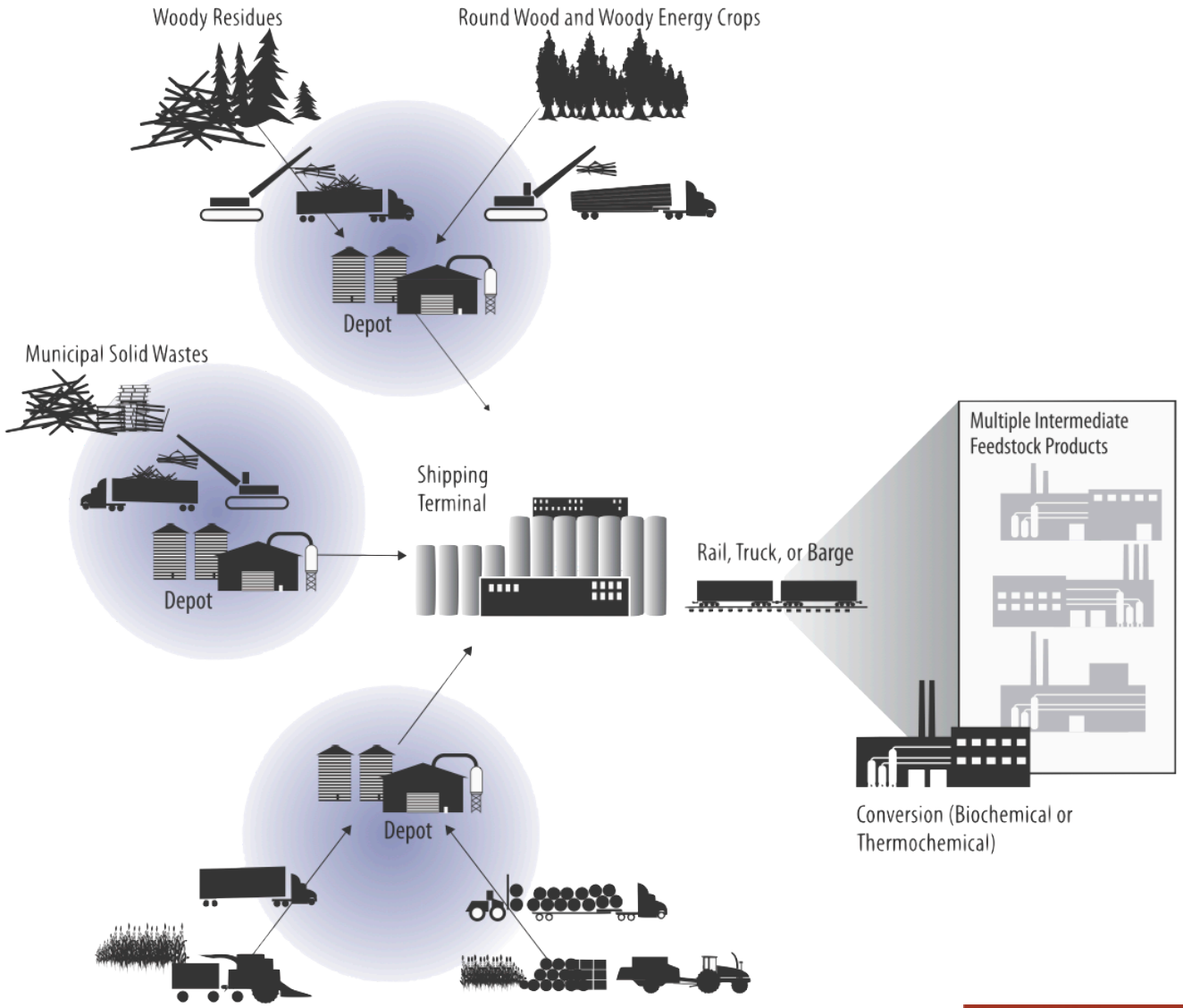
Fundamentals of Micronized Milling for Saccharification

Staged Milling Performance

Additional Related Efforts

TODAY'S OBJECTIVES

• Idaho National Lab Depot Concept



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PROS

Low Environmental Burdens

Benefits in Air Emissions & Water Quantity/Quality

Environmental Permitting

Ex: Wood Composites, Dry Milled Corn Ethanol

Energy Densification

Transportation Logistics

Utilize Existing Infrastructure

Sawmills, Wood Composites, Pellet Plants

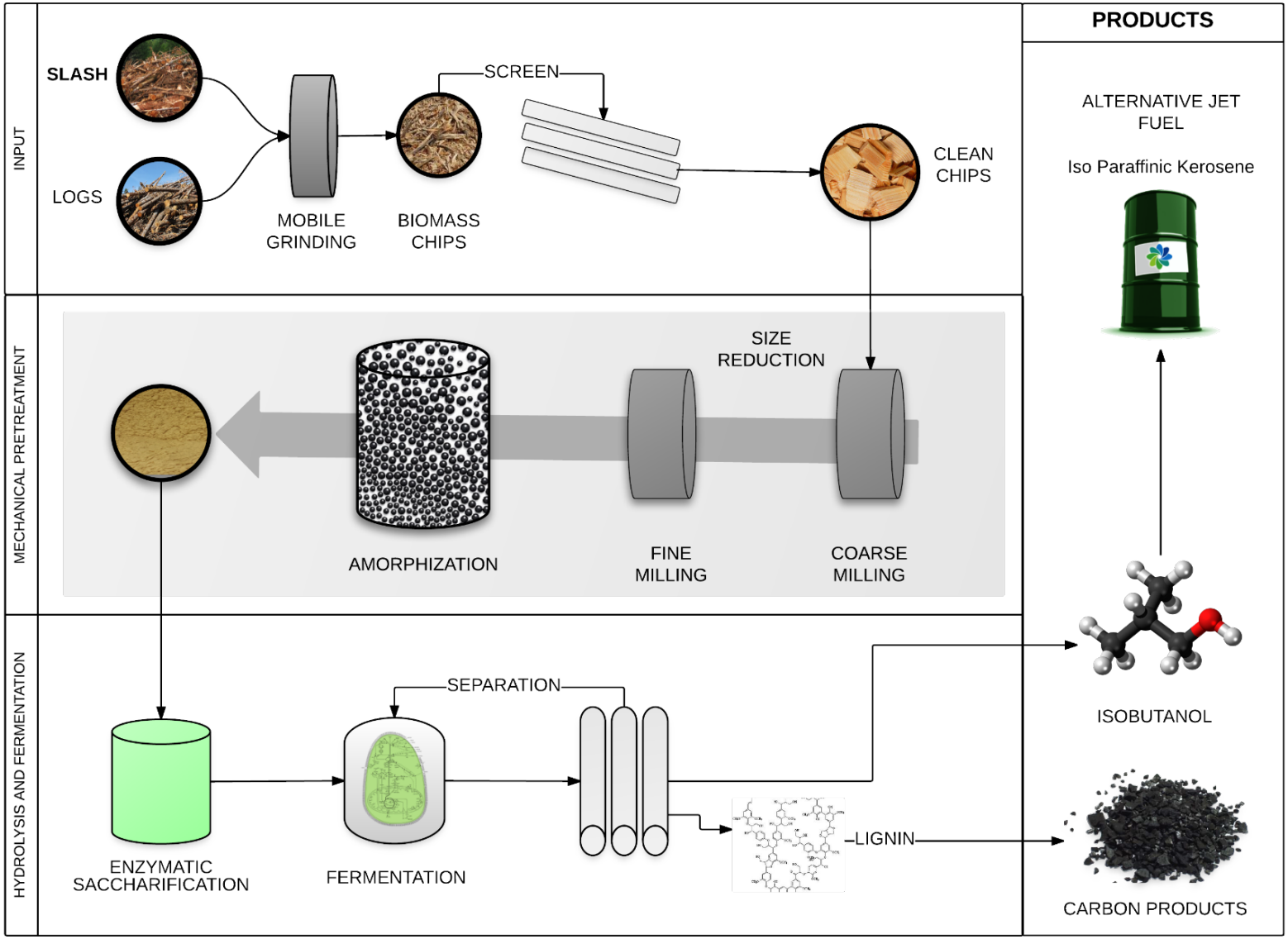
CONS

Known Since 1950's

Energy Intensive

PROS & CONS – DRY MECHANICAL PROCESSES

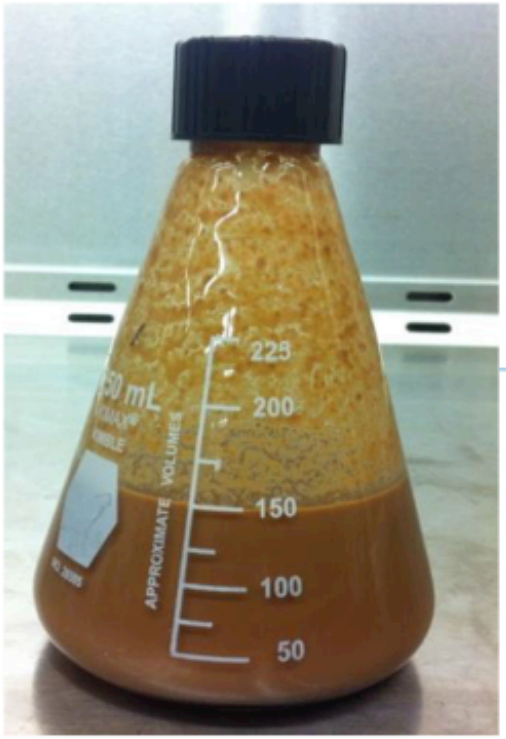
• Milled Wood Depot - Conceptual Process Flow



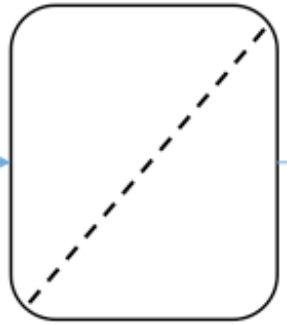
• Staged Milling Strategy

Efficiency Through Optimized Unit Operations

• Clean Sugars and Lignin Rich Residuals



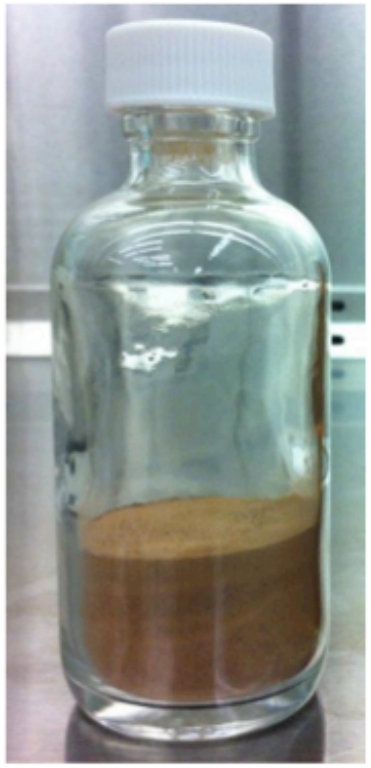
Wood + Enzymes + Water, 48 hours



Separation

Sugars in Water

+



Lignin Residue

Johnway Gao - Weyerhaeuser

Milling Stage Concepts

Sugar and Lignin Production

Particle Characteristics

- *Particle Size Distributions*
- *Particle Morphology*
- *Crystallinity*
- *Ultrastructural Changes*
- *Nanoscale Porosity Changes*

FUNDAMENTALS

• Micronizing by Ball Milling

hammermill

40-min

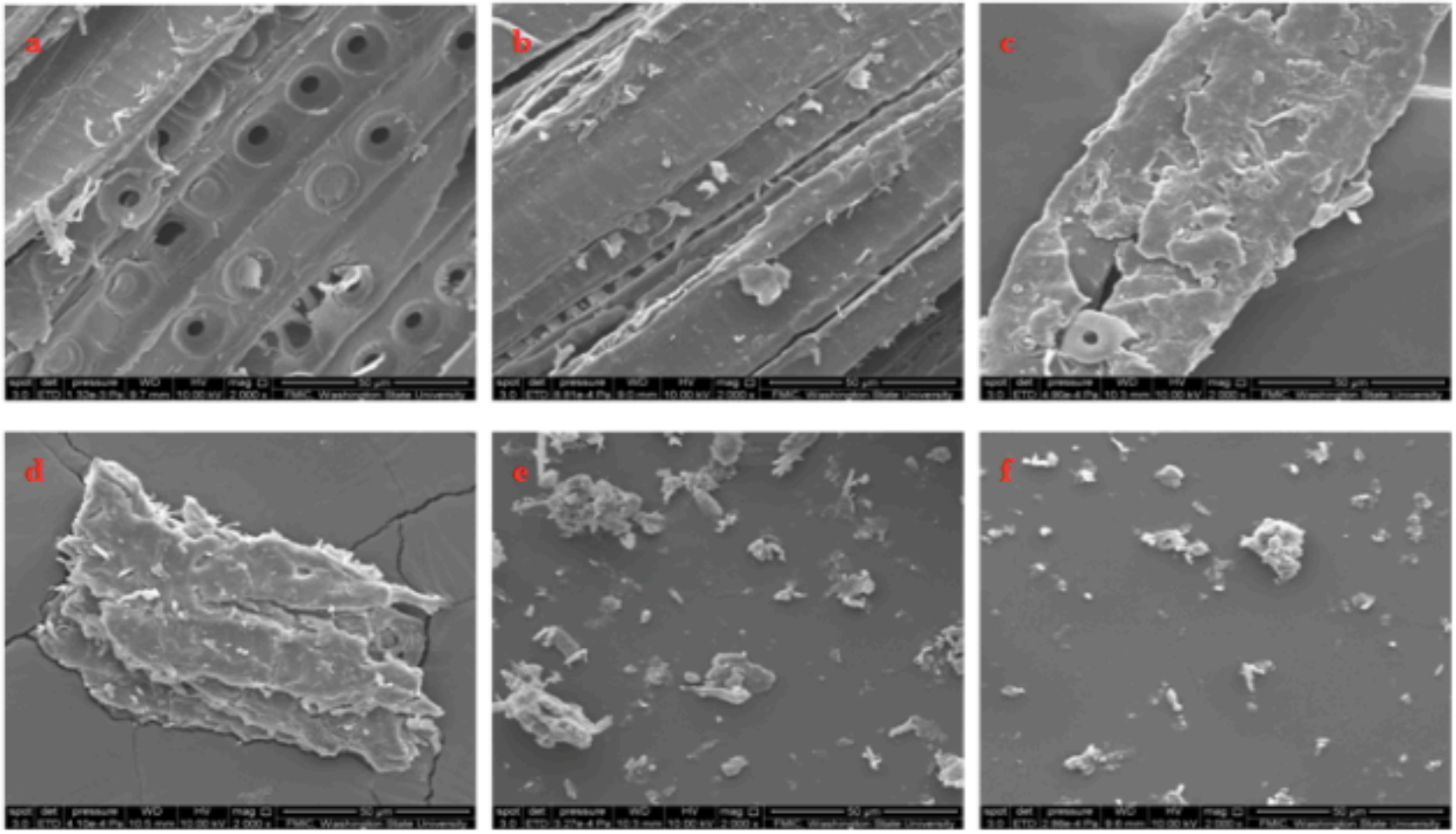
60-min

80-min

80-min
intermittent

120-min
intermittent

• Disrupt Cell and Cell Wall Morphology



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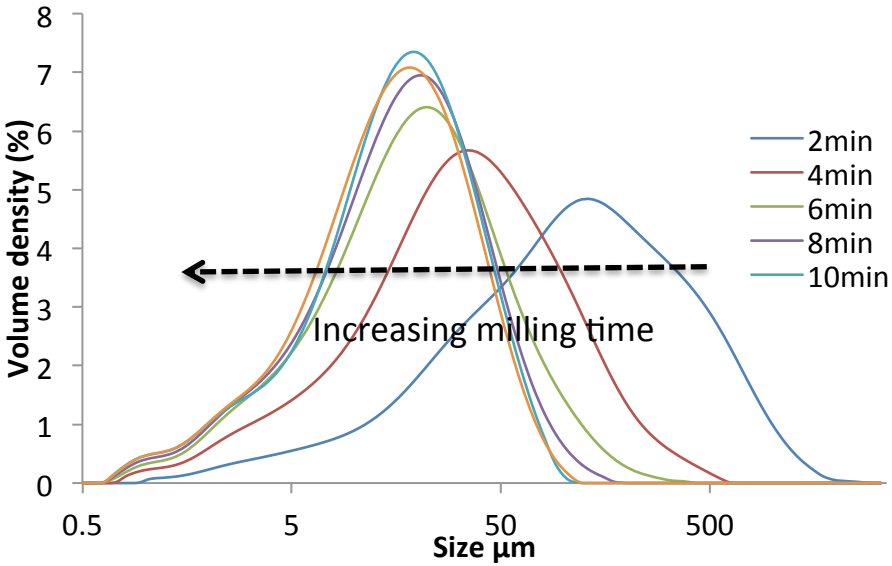
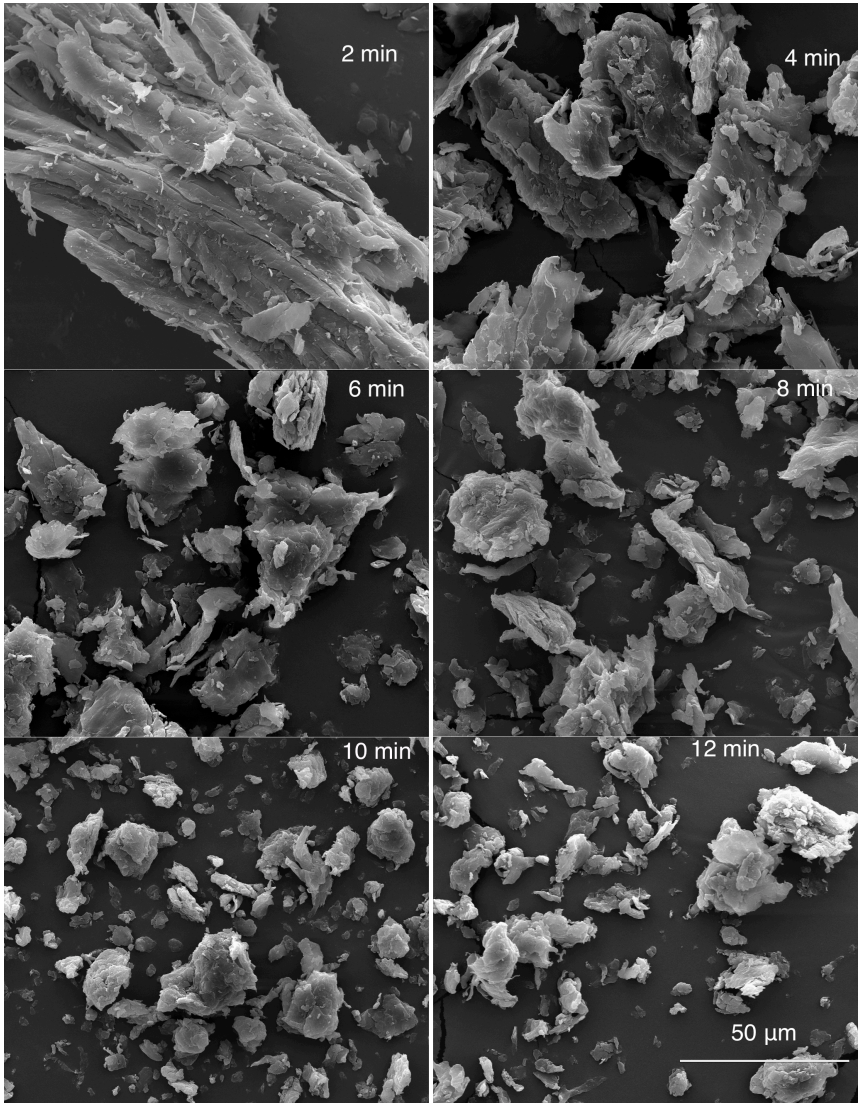
• Particle Size – Ring and Puck Mill

Volume based particle size distribution





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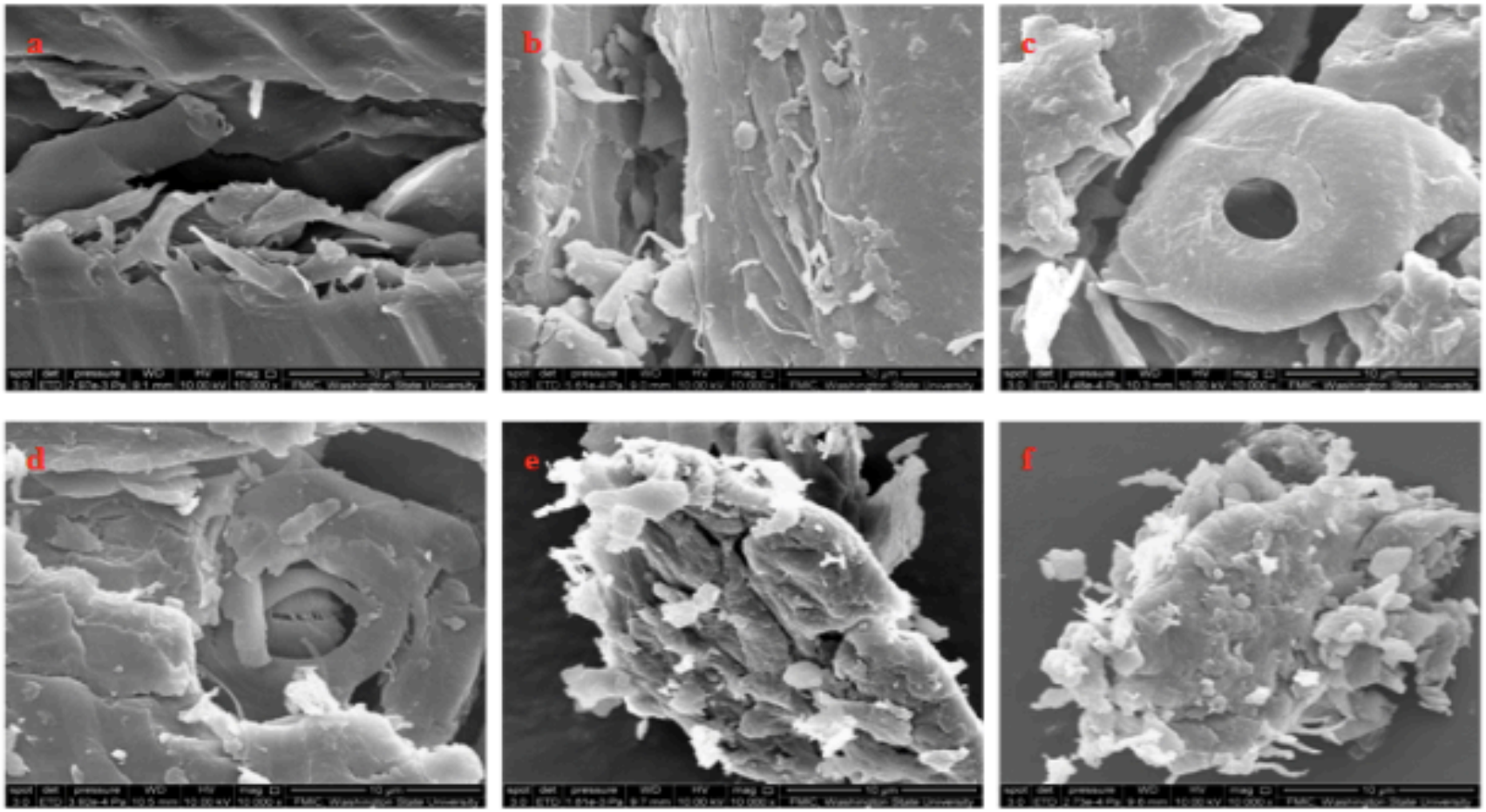
• Disrupt Cell and Cell Wall Morphology



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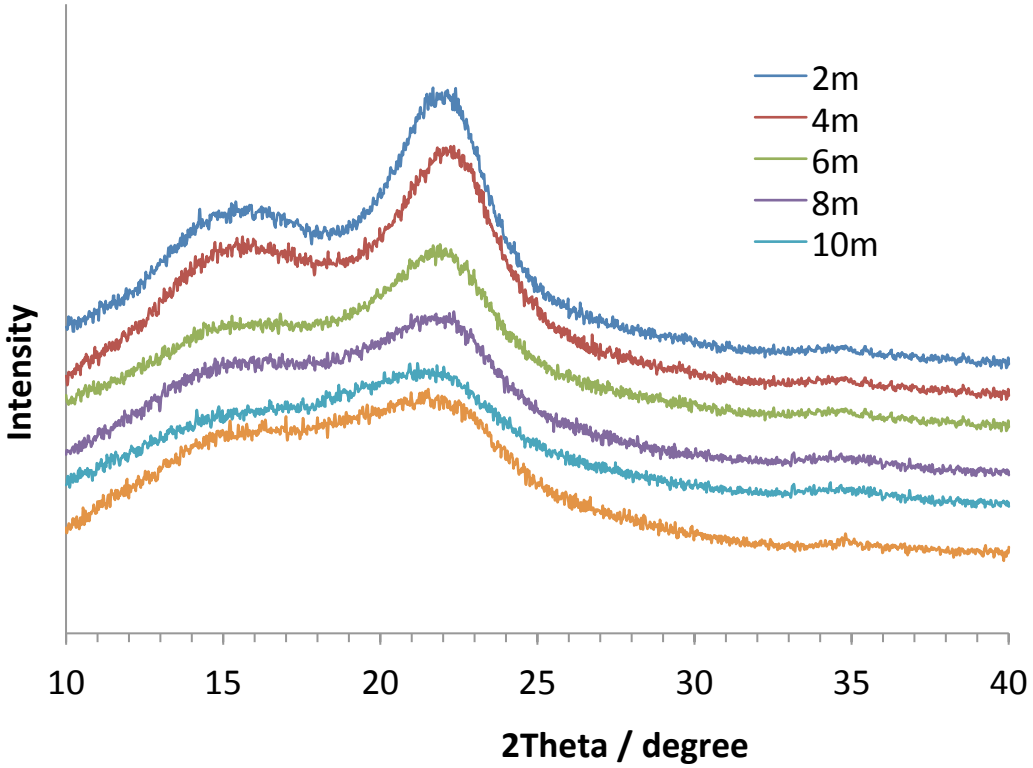
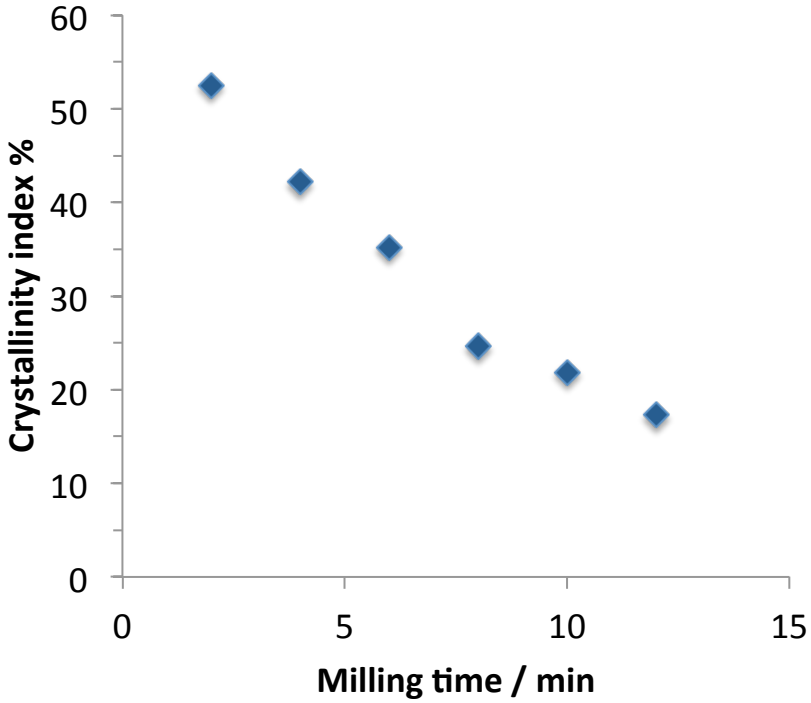
• Crystallinity Index – Ring and Puck Mill

X-Ray Diffraction





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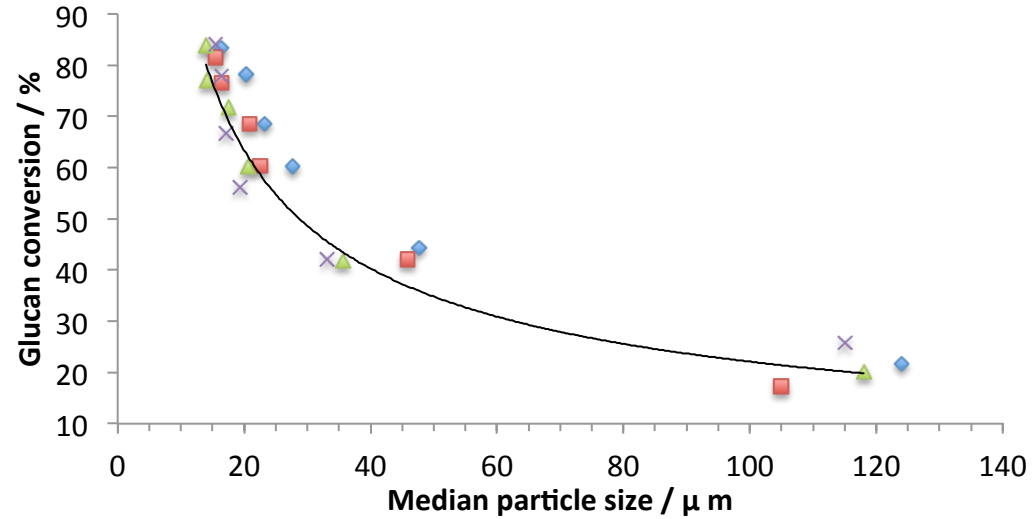
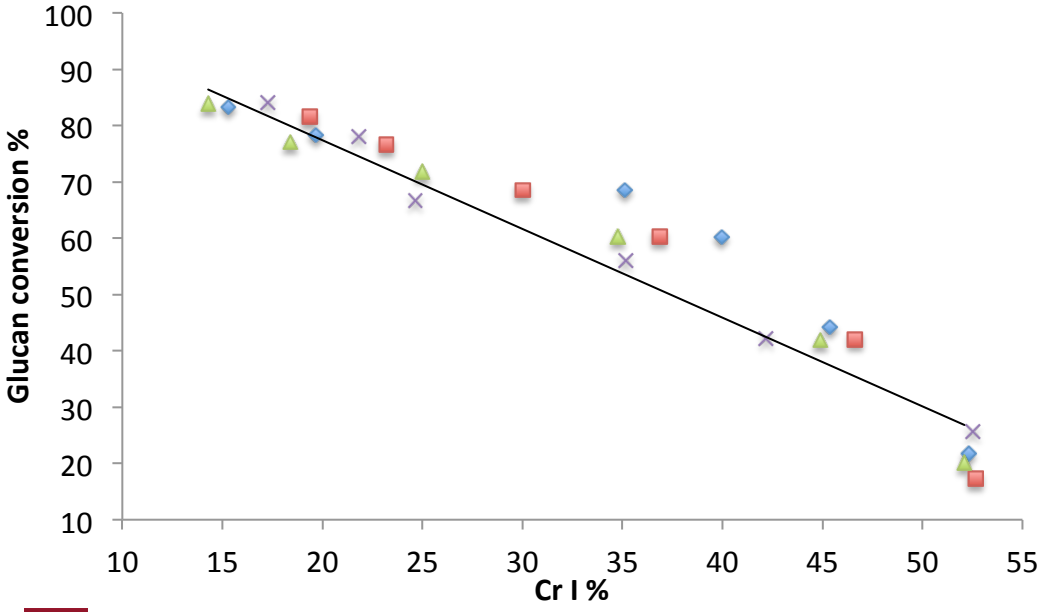
• Factors Influencing Sugar Conversion





Sugar Yield Increases

Decreased Particle Size

Decreased Crystallinity Index

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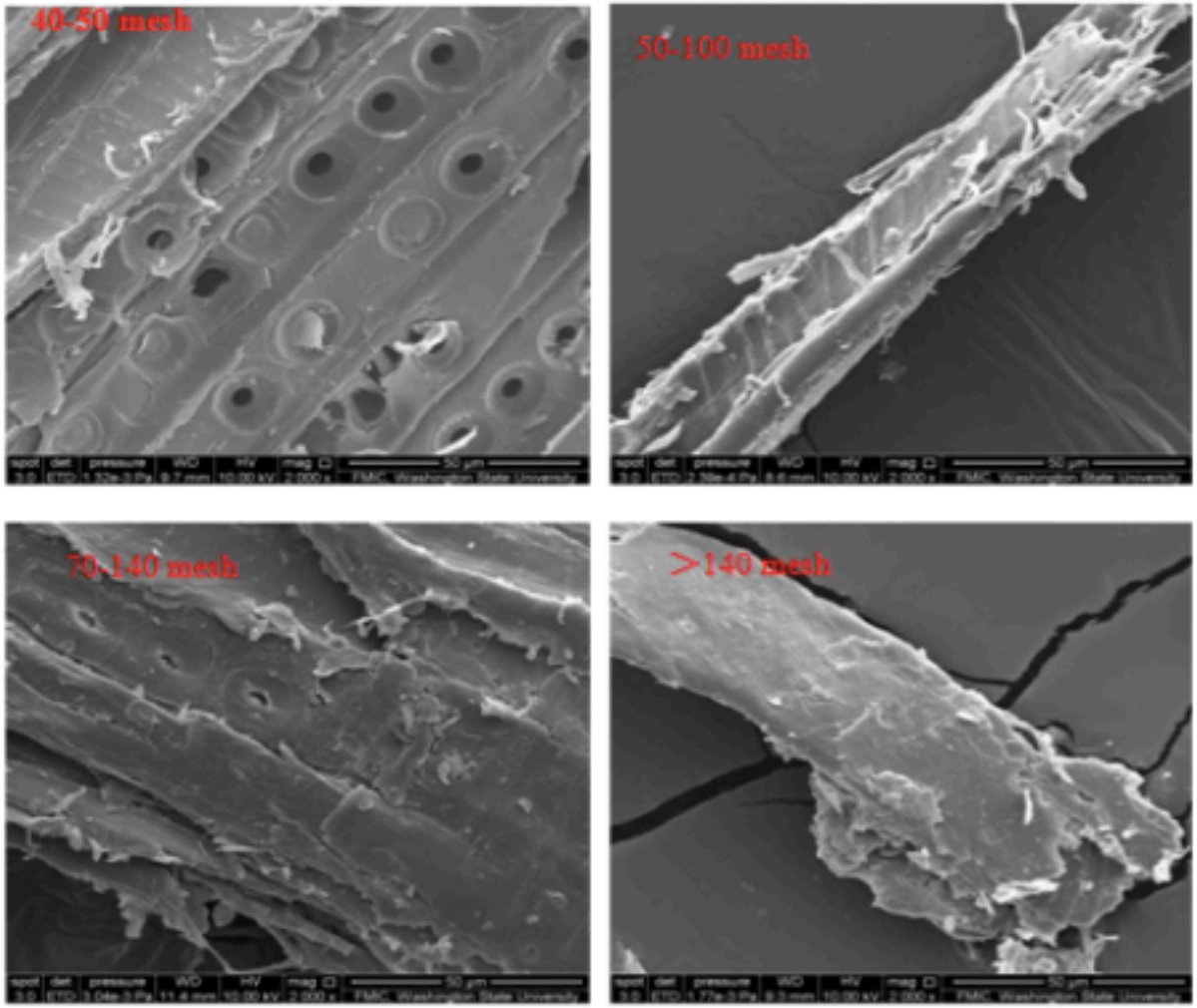
• Hammer Milled Particle Morphology



×2000

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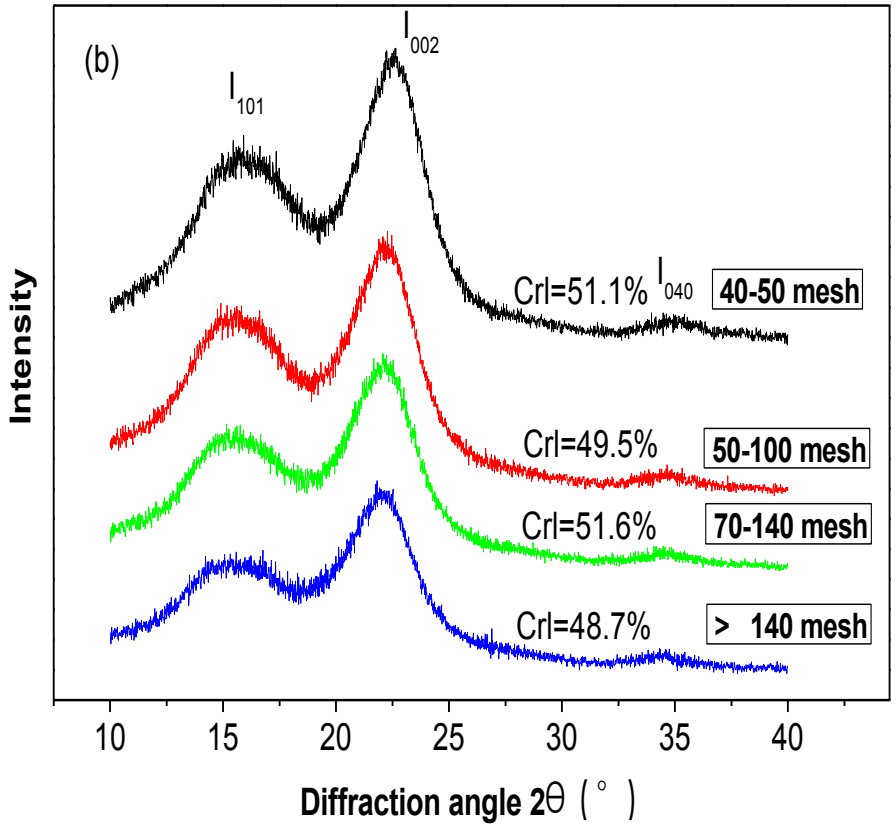
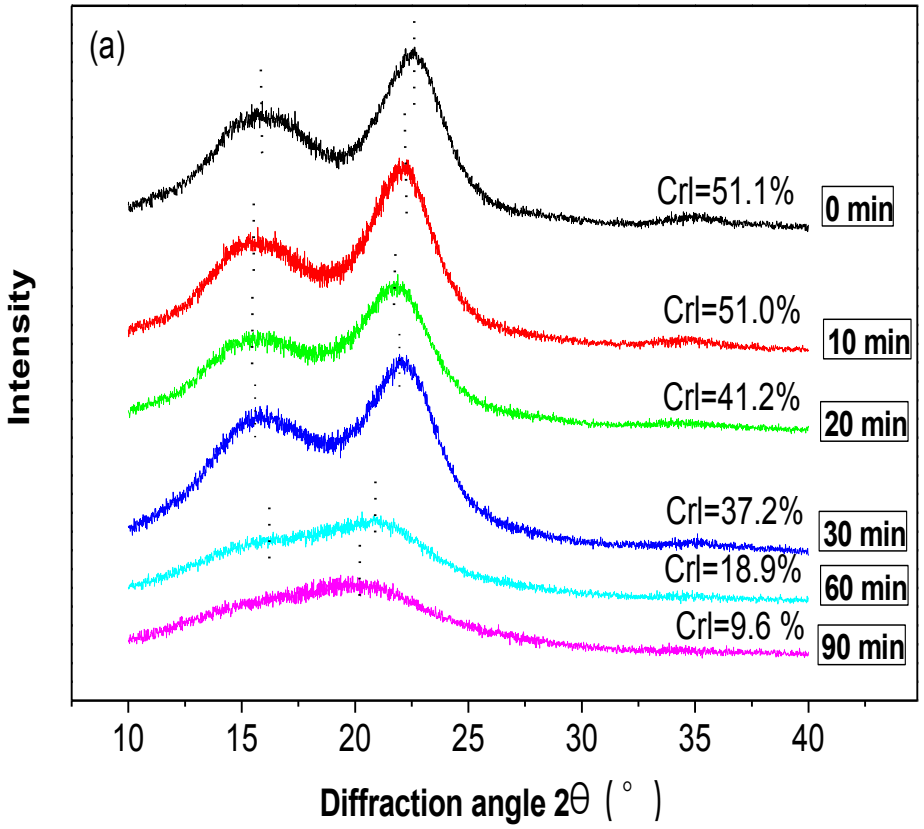
• Hammer Milled vs Media Milled

Hammer Milled Fractions



Media Milling Times



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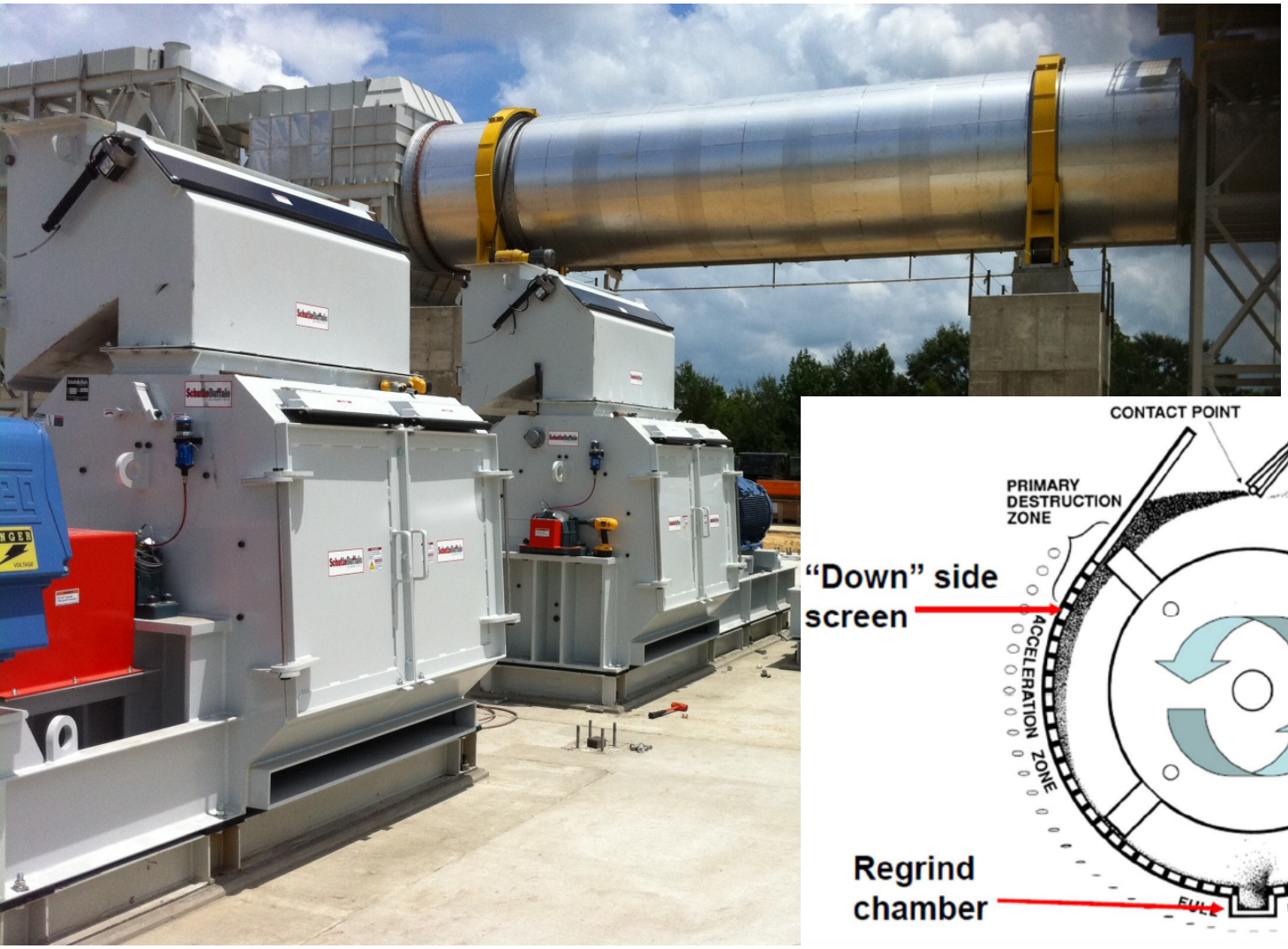
Coarse Milling - Conventional

Fine Milling

Energy Performance in Staged Milling

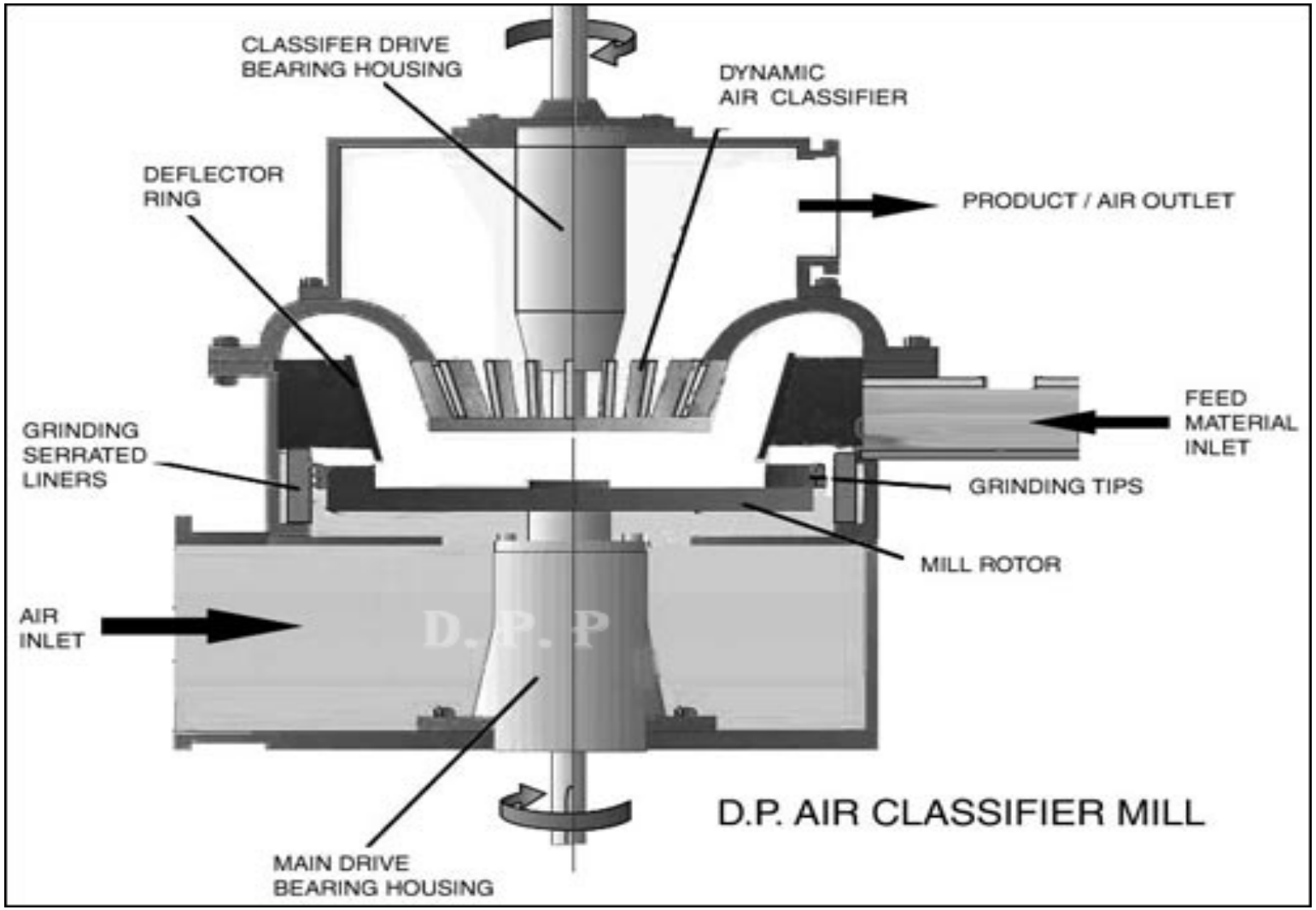
STAGED MILLING STRATEGIES

• Coarse Grinding - Conventional

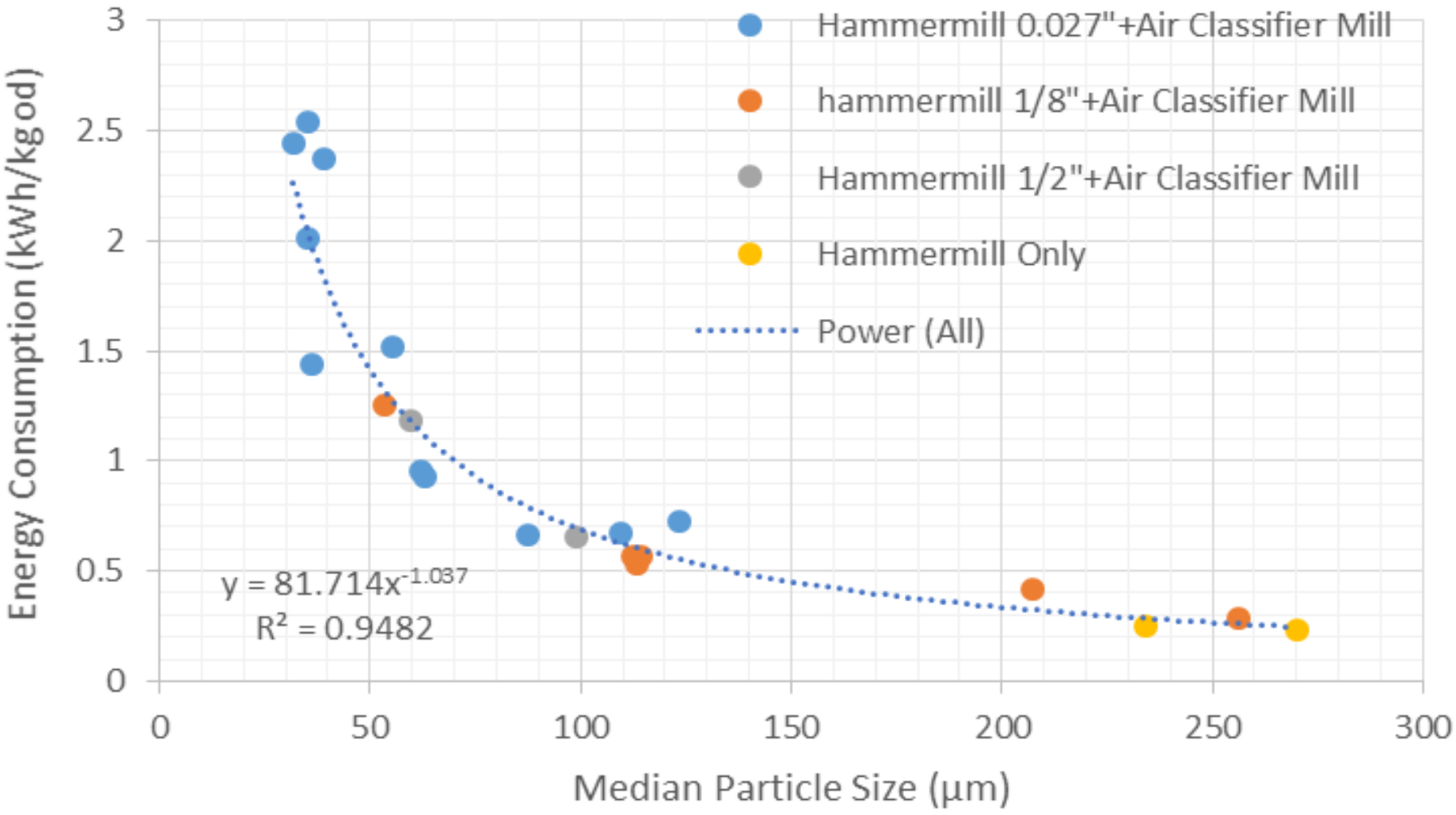


Kior, Columbia MS

• Fine Grinding – Air Classifier Mill



• Two-Stage Milling - Energy



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• Survey of Media Milling Types

Motion	Medium	Material	Scale	Energy	Application
Planetary	Balls, Cylinders	Tungsten carbide, Steel, zirconia, Alumina, Agate	Lab	High	Brittle and ductile materials
Rotary	Balls, rods		Commercialized	Low	Brittle materials
Vibratory **-Circle** **-Elliptical** **-linear**	Balls, rods, cylinders, puck and/or rings		Commercialized	High	Brittle and ductile materials
Agitated mill	Balls, rods		Commercialized	Medium	Wet milling

Saccharification Residuals

- *Isolation of Cellulose Nanofibrils*
- *Production of Organic Acids from Lignin Residuals*
- *Solid Energy Performance*

Influence of Micronized Milling on Chemical Pretreatments

Facility Techno Economic Analysis (TEA)

ADDITIONAL EFFORTS

THANK YOU

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