



CHEMSTONE, INC.

“Chemistry that works for Industry”

X stage—where are they going next?

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Paptac Bleaching Committee

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Overview- Supply

- No major basic enzyme manufacturer is selling direct to the P&P Industry
- Many basic manufacturers sell to several Industry suppliers, a few P&P suppliers have exclusivity
- One P&P supplier has 20+ years of experience in fiber modification in P&P. They are the new Industry leader.
- Some P&P suppliers are simple direct resellers
- But at least one is making down concentrates, blending different combinations, creating new products

So now picking an enzyme supplier is more difficult...what to ask

- Experience in Product AND Application?
- Mill references?
- Lab capabilities
 - Bleaching
 - Matching applications and performance
 - Prove their concepts
- Automated equipment
- Support systems
 - Data analysis
 - Onsite and Lab testing

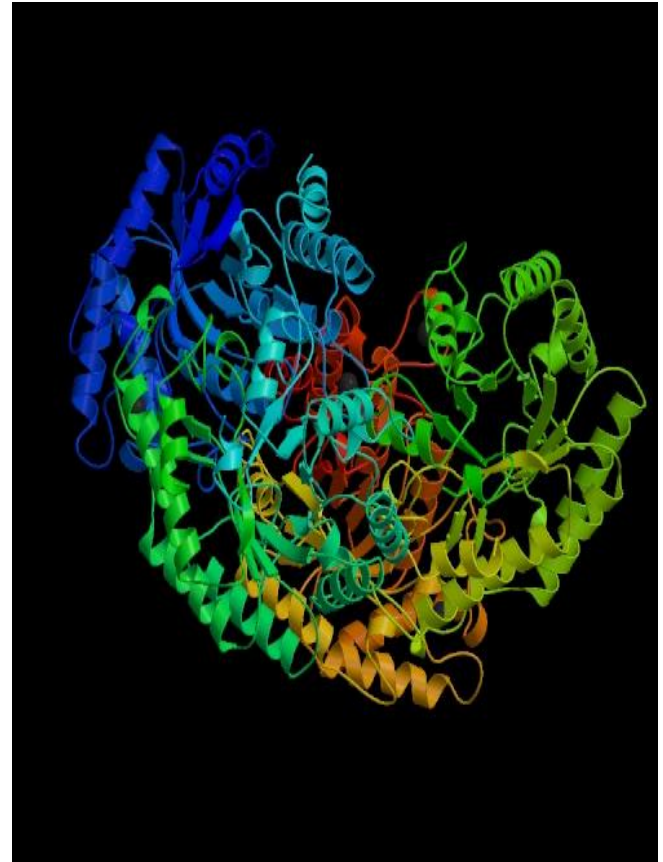
Expectation for Product offerings from a quality P&P supplier

Enzyme Type	pH and Temperature
Endoglucanase with lignin tolerance	4.5 – 7.5 / 30 – 65 °C
Cellulase (Multi)	4.5 – 7.5 / 30 – 65 °C
Cellulase (EG)	4.5 – 8.5 / 30 – 65 °C
Monocomponent Xylanase with varying pH & temperature thresholds	5.0 – 8.0 / 40 – 85 °C
Combination Hemicellulase with variable pH & temperature optimums	4.5– 8.0 / 48 – 74 °C

Fundamentals

What are Enzymes?

- Protein molecules made up of hundreds of amino acids
- Biocatalysts (substances that accelerate certain reactions without being consumed themselves)
- Occur throughout nature, very specific and generally safe
- Functional chemistry given the right conditions

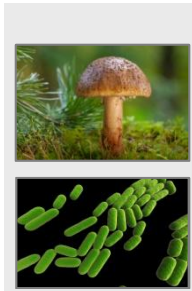


Enzyme creation process

Some P&P suppliers have created alliances with basic manufacturers engaging multiple R&D resources to resolve problems



Nature



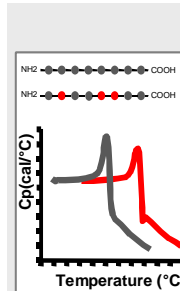
Microorganisms



Wild-type enzymes



Analytical amounts for primary characterization



Optimized enzymes



Production strain



Bulk production



Formulation

Enzyme Creation Process

Key Properties: Sequencing and Folding

- The sequence of nucleotides in the DNA determines the sequence of amino acids in protein
- The sequence of amino acids determines enzyme properties
- Resultant protein is folded in a specific way which determines that enzyme function
- So do the combination of different enzymes generate different results?

Genetic Engineering



...ATGGAA...

DNA



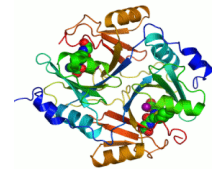
...ATGAAA...

...MetGlu...

Protein



...MetLys...



Improved enzyme



Is there value to combined enzymes?

- Different wood baskets have varying susceptibilities
- Ability to create new applications/grades/markets
 - Chemical cost, strength, brightness, whiteness, less reversion, improved specialty functionality
- Specificity of Application (no side reactions)

Can new value be created with combined enzymes?

Species	a-Cellulose	a-Cellulose	Lignin	Acetyl	Ash	Uronic Anhydride	Galactan	Glucan	Mannan	Araban	Xylan
Hardwoods											
Trembling aspen (<i>Populus tremuloides</i>)	56.5	53.3	16.3	3.4	0.2	3.3	0.8	57.3	2.3	0.4	16.0
White birch (<i>Betula papyrifera</i>)	44.5	41.0	18.9	4.4	0.2	4.6	0.6	44.7	1.5	0.5	24.6
Red maple (<i>Acer rubrum</i>)	44.8	44.1	24.0	3.8	0.2	3.5	0.6	46.6	3.5	0.5	17.3
Softwoods											
Balsam fir (<i>Abies balsamea</i>)	47.7	44.8	29.4	1.5	0.2	3.4	1.0	46.8	12.4	0.5	4.8
Eastern white cedar (<i>Thuja occidentalis</i>)	48.9	45.4	30.7	1.1	0.2	4.2	1.5	45.2	8.3	1.3	7.5
Jack pine (<i>Pinus banksiana</i>)	45.0	41.6	28.6	1.2	0.2	3.9	1.4	45.6	10.6	1.4	7.1
White spruce (<i>Picea glauca</i>)	48.5	44.8	27.1	1.3	0.3	3.6	1.2	46.5	11.6	1.6	6.8

PRE-BLEACH



Features

Latest generations of thermo-stable hemicellulase combinations

Advantages

The opportunity to match species and wood basket to improve susceptibility match for highly effective catalyzing the cleavage hemicellulose polymers. Degrades portion of the hemi present on the fiber surface.

Benefits

Enables bleaching chemicals to more effectively attack lignin in the fiber & removes certain portions where hemi attachment dissolution releases lignin

POTENTIAL BENEFITS

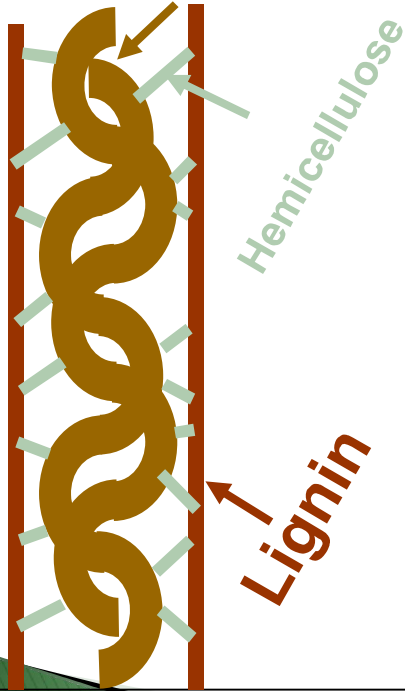
Enzyme Pre-Bleaching

- Increased Brightness
- Increased production where generator limited
- Lower bleaching chemicals/costs

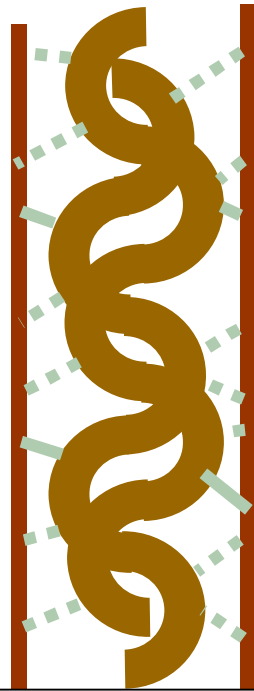
How pre-bleaching enzymes work

Before Enzyme

Cellulose



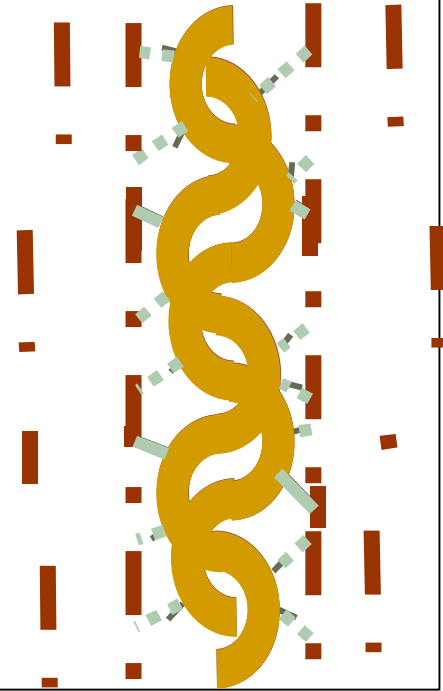
After Enzyme



After Chlorination Do



After Extraction



APPLICATIONS – BLEACHING

1) PULP
SUSCEPTIBILITY

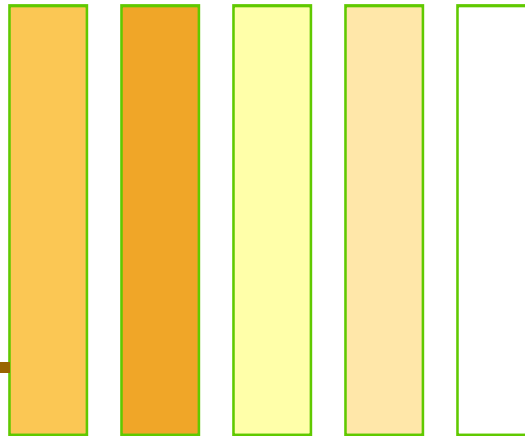
2) ENZYME
SELECTION

3) MIXING AND
DISPERSION

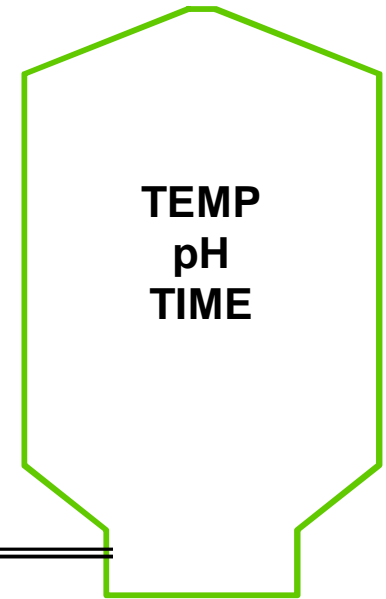
4) REACTION
CONDITIONS



5) BLEACH PLANT
CONTROL



6) REACTION
CONDITIONS



Regardless of where...You must have fit!

Critical process fit has not changed

- Multiple thermo-stable hemicellulases with broad pH range of 6-9 (Optimal 6.5-7.5)
- Temperature range 40-77°C (optimal 45-65°C)
- Minimum contact time 20 minutes
- Low dose range requires near perfect mixing
- No cellulase activity- a taboo no longer?

Post Bleach Enzyme

Enzyme treatment of bleached pulp to enhance brightness and whiteness and reduce reversion prior to the paper machine or pulp dryer

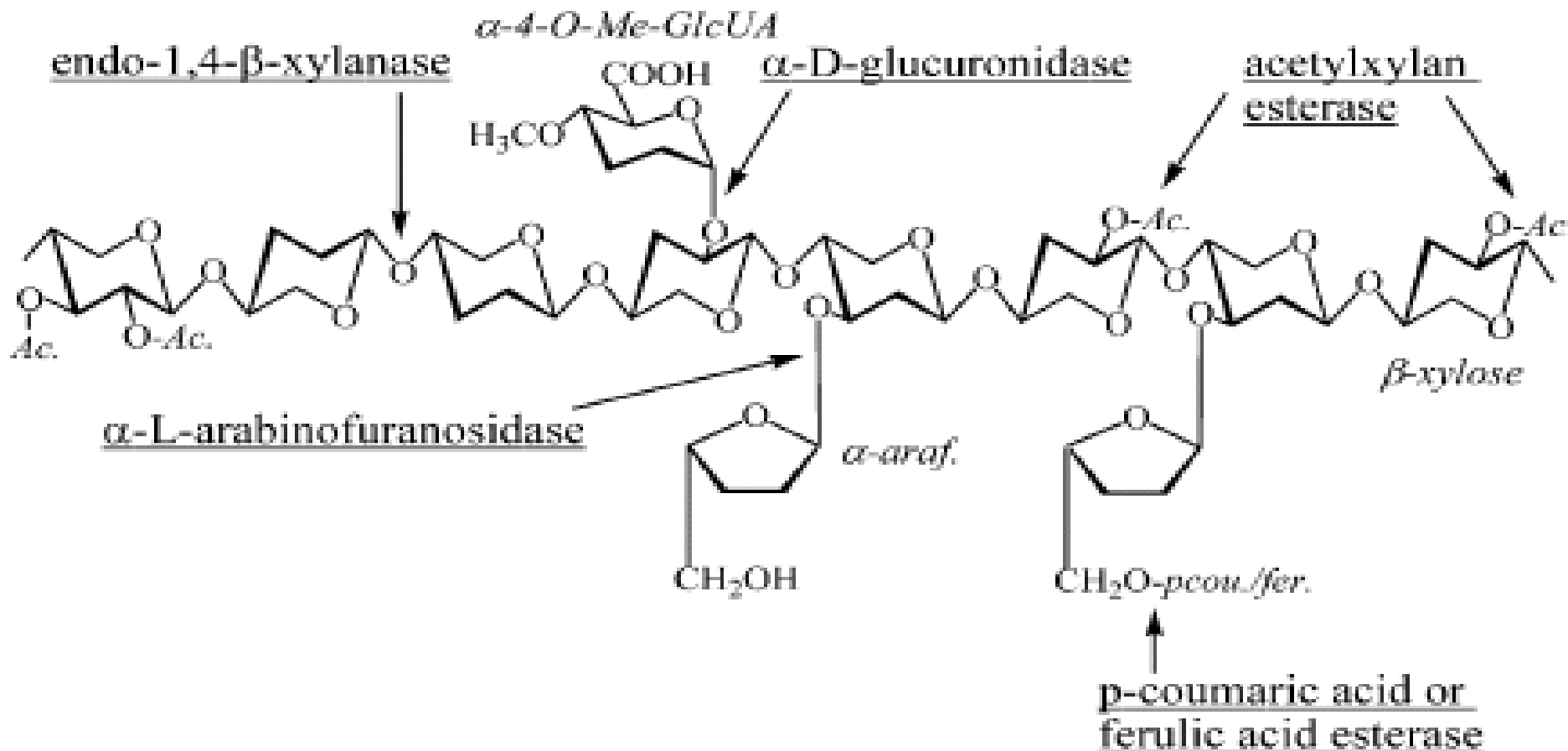
Potential Post Bleach Benefits

- ▶ **Easy fit to most Operations**
 - pH/Temp/retention rarely a concern
 - Typically largest storage is Bleached HD's
- ▶ **Higher Pulp Brightness**
- ▶ **Bleach Plant Chemical savings**
- ▶ **b* reduction**
- ▶ **Less Brightness Reversion**
- ▶ **Operational flexibility**

How Does Post Bleach Work?

- ▶ Residual chromophoric materials remaining in bleached pulp
 - Lignin
 - Degraded carbohydrates
 - Extractives
 - Metals and various oxidizable compounds
- ▶ Conventional bleaching chemicals are not effective
- ▶ Removing enzymatically
 - Boosts brightness
 - Reduces b^* (yellowness)

Potential for removal of Chromophores Attached/Linked to Hemi-Cellulose



That's all folks!

- ▶ **Future may be in combinations:**
 - **Multiple mono components?**
 - **Multi component?**
- ▶ **Industry needs to share their needs & demands**
- ▶ **Remove the conventional barriers to solution**