IMPACT OF CELLULASE ENZYMES ON THE PHYSICAL CHARACTERISTICS OF SOFTWOOD KRAFT FIBER

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OVERVIEW OF ENZYMES

- Protein catalysts
  - not used up
  - specific
- Non-living
- Reduce energy barrier for specific reactions
- Non-hazardous
- Biodegradable
ENZYMES ARE TRUE CATALYSTS

- They are effective in very small amounts
  - Only a few molecules of an enzyme will catalyze the conversion of thousands of molecules of substrate to product each second.
- They are unchanged by the reaction
- They do not affect the ultimate equilibrium concentrations, but reduce the required activation energy and thereby the speed of reactions
- They are very specific with respect to substrate and reaction
VARIABLES IMPACTING PERFORMANCE OF ENZYMES

- Contact time
  - Good mixing at application point
  - More contact time better efficiency

- Temperature

- pH conditions

- Interfering chemicals
  - Oxidants
Cellulase Enzymes for Fiber Modification
CELLULASE FIBER MODIFICATION

- Using cellulolytic enzyme products to condition the fiber, so that mechanical refining can have a greater effect on the fiber.
- Less energy is thus required to reach similar fiber characteristics.
Cellulase degrades cellulose in fiber wall structure, initiates wall stripping & fines generation

Refining then delaminate cell walls and cause cell wall to collapse and starts fibrillation which provides the strength of fiber with more bonding sites
CELLULASE ENZYME ACTIVITY

- Enzymes hydrolyze specific portions of fiber (cellulase enzymes hydrolyze cellulose)
- Cellulase enzymes perform different tasks (exocellulase, endocellulase)
- Enzymes for specific applications must be chosen carefully because the reaction and the rate of the reaction is dependent on the type of enzyme
Case Study
CASE STUDY

- Fully bleached SWK – Southern Pine

- Enzymes: three different enzymes
  - A – multicomponent cellulase
  - B – engineered blend of endo and exoglucanases
  - C – mono component endoglucanase
EXPERIMENTAL

- Enzyme treatment
  - 2% consistency
  - Temperature - 50°C
  - pH – 7
  - 1 Kg/tan OD fiber
  - 1 hour treatment

- Handsheet
  - Made using TAPPI standard T205 sp-06
EXPERIMENTAL

- Scanning Electron microscope
  - 0.3% slurry placed on a carbon adhesive tab mounted on a 25 mm aluminum stub
  - Air dried at room temperature
  - Specimens were gold coated
  - Imaging performed using a JEOL 6480LV SEM
Enzyme Treatment of Bleached SW Kraft Pulp

- Internal Bond
- Fiber Strength

Control | Enzyme A | Enzyme B | Enzyme C

Fiber Strength (n/cm)

Internal Bond (J/m²)
SEM micrographs of untreated fibers collected at 15kV: (a) 250X, (b) 500X and (c) 850X. The untreated fibers had a general absence of fibrillation interconnecting the fibers. The fibers were completely intact and showed no evidence of cell wall damage or peeling. While these fibers were partially collapsed due to the drying process required for SEM sample preparation, they retained much of their 3 dimensional structure. Image (c) shows an undamaged longitudinal tracheid with bordered pits extending the entire field of view.
SEM micrographs of Enzyme A (multi-component cellulase) treated fibers collected at 15kV: (a) 250X, (b) 500X and (c) 850X. The Enzyme A treated fibers displayed increased amounts of fibrillation and fiber collapse that could contribute to interfiber bonding. The fibrillation appeared primarily as small strands interconnecting adjacent fibers. Image (b) shows evidence of outer cell wall damage. While image (c) shows one example of a broader patch of outer cell wall material interconnection two fibers can be seen, this was uncommon.
SEM micrographs of Enzyme B (engineered blend of endo and exoglucanases) treated fibers collected at 15kV: (a) 250X, (b) 500X and (c) 850X. The Enzyme B treated fibers displayed increased amounts of fibrillation and particularly with respect to the broader patches outer cell wall material interconnection fibers. Increased degrees of fiber collapse and cell wall degradation were also evident.
SEM micrographs of Enzyme C (mono component endoglucanase) treated fibers collected at 15kV: (a) 500X, (b) 850X and (c) 850X. The fibrillation seen in the Enzyme C treated fibers appeared as web like structures consisting of broad patches of outer cell wall material. Images (b) and (c) clearly show evidence of outer cell wall peeling.
SEM micrographs of Enzyme C (mono component endoglucanase) treated fibers collected at 15kV: (a) 250X and (b) 500X. The Enzyme C (mono component endoglucanase) treated fibers displayed a dramatic increase in the degree of fiber collapse to the point that the underlying fibers can be seen through the top fibers. The Enzyme C treated fibers were more flexible as demonstrated by the level of conformability of the top fibers to the underlying fibers in image (a).
CONCLUSIONS

- Each of the different enzyme treatments had a unique impact on the sheet properties and the physical characteristics of the fibers.
- The mixed cellulase products promoted fibrillation as evidenced by the increase in the appearance of small fibrils interconnecting the adjacent fibers.
- Treatment with the monocomponent endoglucanase enzyme resulted in extensive fiber wall peeling, fiber collapse and increased fiber flexibility.
CONCLUSIONS

- The impact of the engineered cellulase blend was in between that of the naturally occurring cellulase mix and the monocomponent endoglucanase which is consistent with the product composition.
- This study revealed that specific sheet properties can be achieved by manipulating the exact cellulase enzymes contained in a multicomponent cellulase blend.
Thank You

Questions??