SOME PRELIMINARY DATA ON THE ENZYMATIC HYDROLYSIS OF *PINUS PINASTER* KRAFT PULP

IULIANA SPIRIDON [*] and ANA PAULA DUARTE [**]

[*] "Petru Poni" Institute of Macromolecular Chemistry, Iasi-6600, Romania
[**] Beira Interior University, Department of Science and Paper Technology, Covilha, Portugal

Received July 16, 2003

Enzymes' applications in pulp and paper manufacturing processes and products is gaining global attention. In fact, several applications, including pitch deposits, drainage enhancement, deinking of wastepapers, pulp bleaching enhancement and modification of fibers' characteristics are already used at industrial level.
Enzymes are being produced on a commercial scale and are available at a relatively low price. Research to establish the effect of enzymatic treatment continues in an effort to increase knowledge about the action of enzymes.
The present paper, an additional contribution to this field, studies the potential utilization of hydrolytic enzymes to enhance the fiber characteristics derived from *Pinus pinaster* kraft pulp.

Key words: xylanases, cellulases, *Pinus pinaster*, fiber properties, kraft pulp.

INTRODUCTION

In Portugal, pulp and paper industry uses especially two wood species, *Eucalyptus globulus* and *Pinus pinaster*.

The pulps from the first species are bleached and used for photocopy and written papers, while the second species gives pulps with bad bleachability (compared with other softwood common species, like *Pinus sylvester*), that are used for packaging papers. There is a need to improve the paper-making quality of this pulp to retain and/or improve its competitive advantages on the market.

The treatments with different hydrolytic enzymes could improve bleaching capacity and other properties of softwood kraft pulp.[1-7]

That is why, some enzymatic preparations were used to identify their influence on the pulp properties. In this paper, the results on the possible improvement of

Pinus pinaster kraft pulp's properties by the use of some hydrolytic enzymes are presented.

EXPERIMENTAL

Material

The chips of *Pinus pinaster* wood (30x10x3 mm) were cooked under conventional kraft conditions: 20% alkali active, 10%, sulfidity, 5:1 liquor-to-wood ratio, heating for 90 minutes from room temperature to 170^0, with the reactor maintained at this temperature for 90 min. Pulp's kappa number of pulp – 46.2.

Enzymatic treatment

Enzymatic treatments were performed at a temperature of 50^o, reaction time – 90 minutes, pH = 5 (adjusted with 0.1 N H_2SO_4), pulp consistency –10%, on using two enzymatic preparations, Cartazyme HS (with xylanasic activity) and Novozym (with cellulasic activity), at the same dose – 0.05 IU/g pulp.

Reference pulp was similarly treated, without the addition of enzymes.

Pulp analysis

The Kappa number and viscosity were determined according to Tappi methods: T 236 cm-85 and T 230-om 89, respectively. Handsheets were obtained (T 205 om-889), their strength properties being evaluated by Tappi methods, as follows: T 403 om-91 – burst, T 404 cm-92 – tensile and T 496 cm-85 – tear resistance. The beating degree was determined according to a SCAN C19-65 standard, while brightness was measured with a Technidyne ISO 2 colorimeter. Determinations of fiber's morphology were realised on a MorFi LB01. After pulp hydrolysis with TFA, the polysaccharides content was determined by HPLC (Perkin Elmer 250 chromatograph equipped with Polysphere OH-PB column by Merck Co.).

RESULTS AND DISCUSSION

Effect of enzymatic treatment on viscosity and pulp properties

The effect of enzymatic treatments on pulp delignification and viscosity is presented in Table 1.

TABLE 1

Kappa number and viscosity of pulp after enzymatic treatments

Sample	Kappa number	Viscosity, mPa·s
Reference	45.41	30.92
Cartazyme HS treated pulp	42.69	30.41
Novozym treated pulp	42.45	26.72

A comparison of the control pulp with the enzyme-treated pulps showed a higher level of delignification.

The decrease of kappa number after treatment with Cartazyme HS was of 3 points, being accomplished by maintaining the viscosity values while, for the treatment with Novozym, an important reduction of viscosity was obtained (for the same value of the kappa number).

The viscosity evolution is confirmed by fiber morphology's modifications, presented in Table 2.

TABLE 2

Fiber morphology modifications after enzymatic treatments

Sample	Fiber average length, mm	Coarseness, mg/m	Fines content, %
Reference.	2.404	0.267	1.97
Cartazyme HS treated pulp	2.226	0.238	3.94
Novozym treated pulp	2.019	0.209	4.87

Since fines' component of the reference pulp was low (1.97 %), the enzymatic treatments determined an increase of this fraction, probably due to fiber fibrillation, leading to freeness increase, as shown in Figure 1.

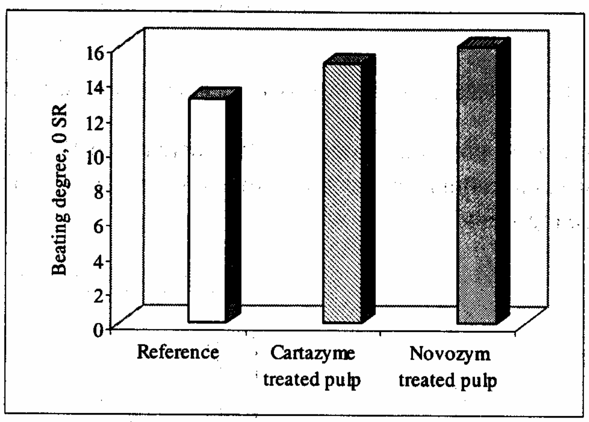

Fig. 1 – Influence of the enzymatic treatment on the beating degree.

Also, after enzymatic treatments, reductions in fiber length and coarseness were assessed. Coarse fibers provide poor interfiber bonding,[8] while the reduction in fiber length had consequences in both fiber strength (measured as zero-span breaking length) and sheet strength (measured as breaking length).

Thus, the fiber strength as zero-span breaking length was 4.24 km for Cartazyme HS-treated pulp and 3.62 km for Novozym-treated pulp, both lower than that of reference pulp (4.67 km). The alteration of fiber strength, as indicated by zero-span tensile measurements, demonstrated that applications of enzymatic treatments had reduced the intrinsec fiber strength.

Reduction of breaking length (Fig. 2) for Novozym-treated pulp is probably due to the decrease of intrinsic strength, fiber defibrillation and fines hydrolysis, which is more intense due to the cellulase component from this preparation, acting preferentially on finer, thinner walled fiber .[6]

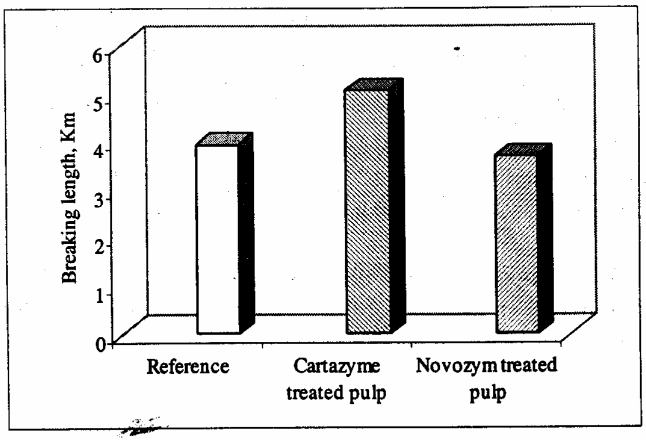

Fig. 2 – Influence of the enzymatic treatment on breaking length.

Both enzymatic preparations caused the increase of the tear index (Fig. 3), whereas significant reductions in burst index (Fig. 4), as compared with the reference, were registered.

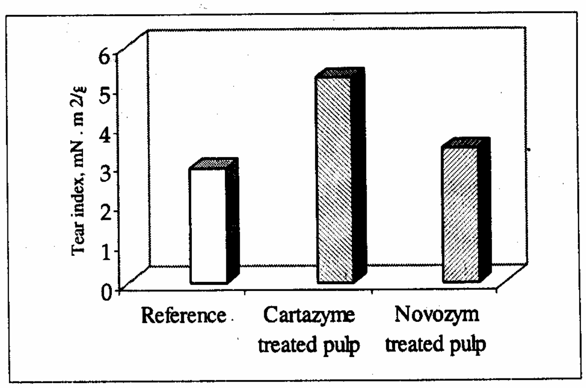

Fig. 3 – Influence of the enzymatic treatment on tear index.

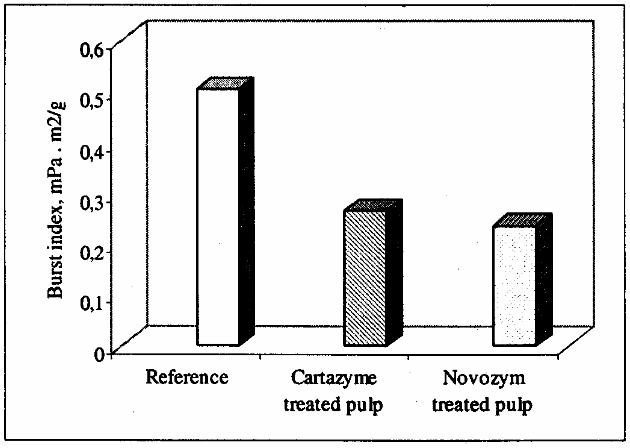

Fig. 4 – Influence of the enzymatic treatment on burst index.

Influence of enzymatic treatments on the optical properties

The light scattering coefficient is influenced by the amount of unbound surface. Increasing, as a result of enzymatic treatments, of interfiber bonding, reduced the amount of unbound surface, with consequences on the light scattering coefficient.[9-10] Also, decrease in the hemicellulose content (Table 3) contributed to the alteration of this optical property, as seen in Figure 5.

Hemicelluloses increase the area of interfiber contact, participating to the interfiber bonds and filling out the void space at the contact areas. This improves interfiber bonding and strength properties, that mainly depend on it (tensile and burst). During treatment with hemicellulase, different amounts of hemicelluloses are solubilised (Table 3), as a function of the used enzymatic preparation.

Trial results indicate that all enzymatic treatments improve pulps' brightness (Fig. 6).

TABLE 3

Sugar released by enzymatic hydrolysis

Enzymatic preparation	Sugar solubilised, mg/g				
	Glucose	Xylose	Galactose	Arabinose	Mannose
Novozym	32.40	1.72	0.82	1.23	0.78
Cartazyme HS	8.43	13.96	0.48	1.08	0

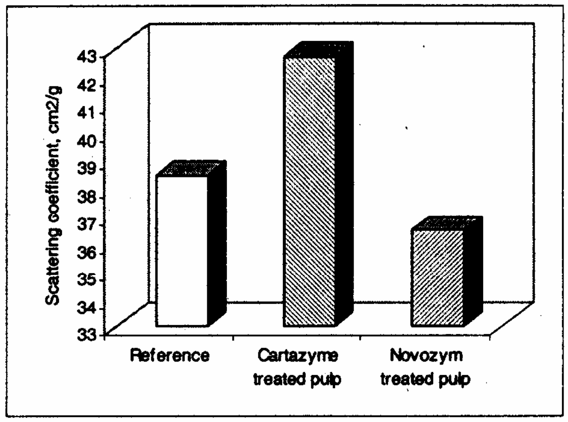

Fig. 5 – Influence of the enzymatic treatment on the light scattering coefficient.

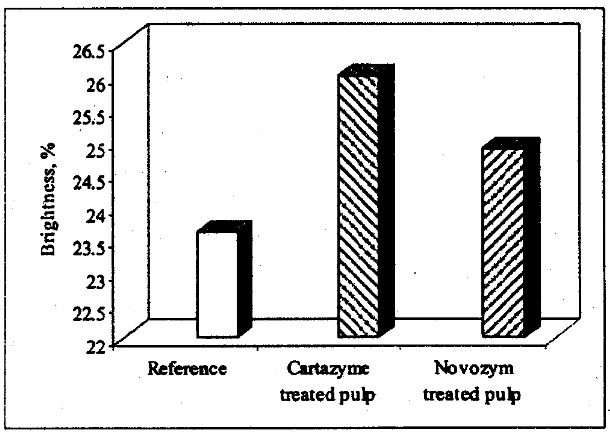

Fig. 6 – Influence of the enzymatic treatment on brightness.

CONCLUSIONS

The enzymatic treatment of *Pinus pinaster* kraft pulp with both enzymatic preparations improved the pulp delignification level, on maintaining viscosity in the case of Cartazyme HS. Fiber's morphology was more affected by the Novozym treatment, this influencing papermaking properties. The increase of brightness was registered for both enzymatically-treated pulps.

Such preliminary data lead to the idea that optimisation of the enzymatic treatment conditions could improve *Pinus pinaster* kraft pulp properties.

REFERENCES

1 J. Buchert, E. Berguore, G. Lindblad, L. Viikari and M Ek, *Tappi*, **89**, 165 (1997).
2 A. Kantelinen, B. Hortling, J. Sundquist, M. Linko and L. Viikari., *Holzforschung*, 47, 318 (1993).
3 R. P. Kibblewhite and Ken K.Y.Yong, *Appita J.*, **52**, 300(1999).
4 S. D. Manfield, A. R. Dickson and J. N. Sadler, *Proceedings of 7th International Conference in the Pulp and Paper Industry*, Technical Section, CPPA, vol.1, pp. 182-192 (1998).
5 S. D. Manfield and J. N. Sadler, *J. Pulp Paper Science*, **25**, 84 (1999).
6 J.Pere, M. Siika-aho, J. Buchert and L. Viikari, *Tappi J.*, **78**, 71 (1995).
7 I. Spiridon, A. P. Duarte and M. N. Belgacem, *Appita J.*, **54**, 457(2001).
8 R. Seth, *Material Research Soc.*, **197**,143(1990).
9 S. A. Rydholm, in "Pulping Processes", R.E. Krieger, Ed., Malabar, Fl.(1985).
10 R. A. Stratton, *International Paper Physics Conference Proceedings*, Tappi Press, Atlanta, p. 561 (1995).