ABSTRACTS

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MODIFICATION OF SECONDARY PULP FIBRE FRACTIONS BY ENZYMATIC TREATMENT

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Introduction

Paper industry is already absorbing a considerable amount of secondary fibre disposals. However, the papermaking process and the repulping/drying cycles are known to modify the wood fibre properties [6]. Generally, the recycled paper quality is lower, and the manufacture methodologies are more demanding and expensive [4]. Unfortunately, these factors limit waste paper re-utilization unless a substantial secondary fibre upgrade is achieved before its incorporation in production.

For that matter, the use of enzymes, namely cellulases, is a promising alternative [1, 2, 3, 4]. So far, it has not been possible to simultaneously increase the pulp drainage ability and the paper resistance, as the former is often obtained at the expense of the latter. The most probable way to achieve this purpose is the selective enzymatic action on the fibre [1, 5, 7, 8]. The extent of the fibre modification during an enzymatic treatment is highly dependent on the pulp composition, the enzyme properties and the experimental conditions (eg. temperature, period of reaction). Also, as suggested in previous publications, cellulases may act preferentially on the fines and short fibre fraction of the pulp, while the long fibre fraction, more resistant to the enzyme treatment, would remain substantially unaffected [2, 7, 8].

In order to enhance the selectivity of the enzyme performance, a secondary paper pulp was fractionated and treated with enzyme. The objective of the present work is to compare the effects of the enzyme treatment on individual fibre fractions and on non-fractionated samples.

Methods and Materials

Paper source

The paper pulp used in this study was kindly supplied by the paper company *Portucel Viana* and consisted on old paperboard containers (OPC), representing a mixture of 60% Kraft paper, 20% flutting and 20% test liner.

The sample was fractionated using a Bauer-McNett fibre-length classifier, and the > 30 mesh and the 200 – 50 mesh fibre-length fractions were collected (Tappi 233 cm-82).

Enzymatic treatment

The enzymatic treatment of the fractionated and non-fractionated pulps was performed in the presence of a commercial cellulase from *Trichoderma reesei, Celluclast 1.5L* (Novo Nordisk). The enzymatic reaction took place for 30 minutes, at pH 5.0, 3% consistency and continuous slow mixing. To inactivate the enzyme, the pulp was boiled. Samples were recovered by dewatering in a vacuum filter and the filtrate was kept to quantify cellulose solubilisation during treatment. In order to conveniently estimate the enzymatic action, control assays (with denatured enzyme) were made in parallel.

Process evaluation

The enzymatic modifications of the pulp samples were evaluated by determining parameters as drainage rate, burst, tensile strength, tear, sheet density and permeability to air flow (ISO 5267/1, ISO 2758, ISO 1924/2, ISO 1974, ISO 534 and ISO 5636/3, respectively).

Results and Discussion

Previous reports suggested a preferential degradation of fines and shorter fibre from pulps by the enzymes [1, 14], as a consequence of the higher surface area of these particles. The present study shows the response of two fibre-length fractions to the enzymatic treatment and compares these results with the ones obtained with the enzymatic treatment of the unclassified pulp. The reactions took place in the presence of different dosages of *Celluclast 1.5L* (0.4, 1.0 and 2.0 FPU per g of dry pulp).

Table 1. Quantification of cellulose degradation (% solubilisation)

Sample \ Enzyme dosage	0.4 FPU	1.0 FPU	2.0 FPU
200 – 50 mesh	0.9	1.8	3.7
> 30 mesh	0.7	1.7	3.2
Non-classified	1.0	1.9	4.0

Table 1 shows the % of solubilised cellulose after the enzymatic hydrolysis. The amount of sugars released was higher for the smaller fibre fraction, which indicates the expected higher affinity of the enzymes for the shorter fractions. However, the unclassified pulp was the further hydrolysed. This might reflect the presence of the fines fraction, lost during fibre fractionation by passing the 200-mesh sieve.

Physical testing showed that the fractionated samples and the original pulp responded similarly to the enzyme treatment (Figure 1). All fibre fractions showed an increase in drainage at the expense of some of the strength. The single significant exception was the tensile strength, which declines after the enzymatic treatment of the mixed fibres pulp but increases in the fractionated samples, especially in the shorter fibre fraction. This has already been reported as the fibre flattening, which enlarges the available surface for bonding and consequently increases the number of effective fibre-to-fibre bonds [12, 13, 21]. The results highlight the importance of the smaller fibre fractions in forming the tighter fibrous network, responsible for a well-bonded, strong paper product.

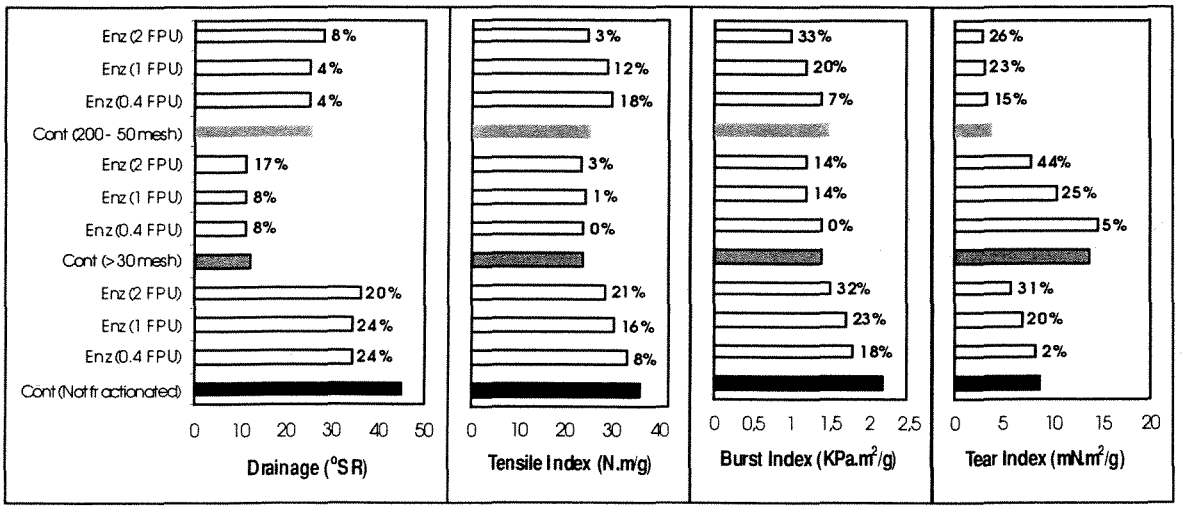

Figure 1: Effect of *Celluclast 1.5L* on the pulp and paper properties fractionated and non-fractionated samples

Increase in enzyme dosage accentuates the described effects. 1.0 FPU is the limiting enzyme concentration as beyond this value both drainage and strength decrease. The tensile improvement observed in the fractionated pulps is also dependent on the enzyme dosage, as the detected benefit tends to diminish with increasing enzyme dosage.

If the smaller fibres fractions are more readily hydrolysed, the fines fraction accounts for the highest hydrolytic rate. This would corroborate with the hypothesis that paper strength depends not only from the

increased bonding, but also from the filler material. If this material is extensively removed, increased bonding is not sufficient to assure fibre strength maintenance.

Conclusions

The obtained results revealed that, although it was possible to increase the whole pulp drainage rate, sheet strength properties decreased with increasing enzyme dosage.

Individual fibre fractions generally showed the same response to treatment as the unfractionated sample. The single significant exception is the tensile index, which was increased by the enzymatic treatment of the fractioned samples. Nevertheless, the lower fibre-length fraction seemed to be more affected by the enzymes than the > 30 mesh fraction, which supports the generally accepted theories on the enzyme action over the fibres.

Acnowledgments

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References

G. Stork and J. Puls (1994) Biotechnology in the pulp and paper Industry, 145-150.

Gerhard Stork, Helena Pereira, Thomas M. Wood, Eva Dusterhoft, Annette Toft and Juergen Puls (1995) *Tappi Journal* 78 (2), 79-88.

Jaakko Pere, Matti Siika-aho, Johanna Buchert and Liisa Viikari (1995), *Tappi Journal* 78 (6), 71-78.

Jean-Claude Pommier, Jean-Luc Fuentes and Gerard Goma (1989) *Tappi Journal* 72 (6), 187-191.

John D. Richardson, Ken K.Y. Wong, Carol P. Robson and Kathryn B. Anderson (1998) *7th Int. Conf. of Biotechnology in the Pulp and Paper Industry* A, A193- A196.

Mousa M. Nazhad and Laszlo Paszner (1994) *Tappi Journal* 77 (9), 171-179.

Shawn D. Mansfield, Alan R. Dickson and John N. Saddler (1998) *7th Int. Conf. of Biotechnology in the Pulp and Paper Industry* A, A189- A193.

Shawn D. Mansfield, Ken K. Y. Wong, Ed De Jong and John N. Saddler (1996) *Tappi Journal* 79 (8), 125-132.